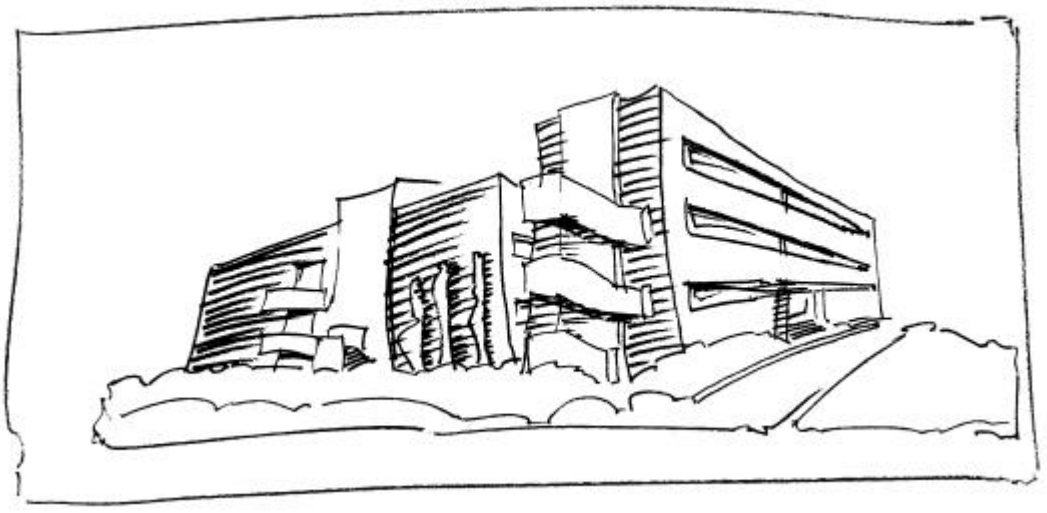
ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS (DEPARTMENT OF CIVIL ENGINEERING)
UNIVERSITY OF LA CORUÑA

ECTS Information Package



Academic year 2001/2002

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- Railways
- Technical French
- Reinforced and Prestressed Concrete II
- Environmental Impact of Engineering Works
- Maritime Engineering
- Nuclear Engineering
- Harbour Engineering
- Geotechnical Engineering III
- Technical English
- Advanced Numerical Methods
- Dams
- Bridges I
- Bridges II
- Urban Services

- Expert Systems
- Urbanism II
- Management and Operation of Harbours
- Computer Aided Design and Visualization
- Optimum Design of Structures
- Railways Technical Operation
- Underground Hydrology
- History of Art
- Engineering of Urban Sewage Systems
- Materials and Constructive Systems
- Rock Mechanics
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- Urbanism I
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1. PRESENTATION and HISTORICAL PRECEDENTS

In this ECTS (European Credit Transfer System) Information Package of the *Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos de La Coruña*, the reader will find information about the School itself, about the degree being imparted and about the organisation of the academic year 2001/2002.

The grade studies leading to the obtaining of the Degree in Civil Engineering, have traditionally been named in Spain as *Ingeniería de Caminos, Canales y Puertos* since 1802. In this year, Agustín de Betancourt (1758-1824) established the *Escuela de Ingenieros de Caminos, Canales y Puertos*, that was first housed in the Royal Palace of *Buen Retiro* in Madrid. The School was founded with the aim of instructing the students, so as to permit them to join the *Cuerpo de Ingenieros de Caminos* (Body of Civil Engineers), in order to *'build and keep the basic infrastructures of the country'*. At the beginning, it was run as an independent institution up to the year 1957, in which it became responsible to the Ministry of Education.

These teaching institutions are now included within the Universities framework, and are still called *Escuelas Técnicas Superiores de Ingenieros de Caminos, Canales y Puertos*, being the only institutions allowed to issue a Degree in *Ingeniería de Caminos, Canales y Puertos*. This degree is the only one that entitles the new engineers to join the *Colegio de Ingenieros de Caminos, Canales y Puertos* (Institution of Civil Engineers), and qualifies them to practice in all the Civil Engineering fields within Spain.

At the moment, there are only nine of these institutions in Spain, i.e. Madrid (1802), Santander (1966), Valencia (1968), Barcelona (1973), Granada (1988), La Coruña (1991), Alfonso X (1996), Ciudad Real (1988) and Burgos (1998). All of them are attached to Public Universities, except for the Alfonso X School, which belongs to a Private University. All of them except for the Madrid School, which is structured into a six-year degree, have an academic programme consisting of five years, at the end of which, the students have to submit an End of Degree Project, in order to obtain the Degree in *Ingeniero de Caminos, Canales y Puertos*).

Some of the aforementioned Universities, and some others which are not in the list, do also offer a three-year degree in Civil Engineering, which is known as *Ingeniería Técnica de Obras Públicas*, that qualifies the new *Ingenieros Técnicos*, in certain Civil Engineering areas.

The *Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos de La Coruña* was created by the Decree 274/1991 of 30th of July, issued by the *Consellería de Educación e Ordenación Universitaria* of the *Xunta de Galicia*, which furthermore granted the authorisation to set up the studies leading to the official degree of *Ingeniero de Caminos, Canales y Puertos*.

The *Escuela de Caminos de La Coruña* began its academic activities in October 1991, provisionally located in the *Laboratorio de Control de Calidad de la Demarcación de Carreteras del Estado en Galicia*, dependent on the Ministry of Public Works, in the locality of Arteixo. The building which currently houses it since 1994, was built in the University Campus of Elviña. The academic year 2001/2002 is therefore the eleventh in the recent history of the School, and this year will see the seventh group of Civil Engineer students being graduated in Galicia.

The privilege which having the current facilities signifies after such a short period of existence would not have been granted without the support that the institutions have given to the School. To the vicechancelorship's of the University of La Coruña and those of the *Colegio de Ingenieros de Caminos, Canales y Puertos*, we have to add those of the City Hall of La Coruña, the Regional Government and the Ministry of Public Works. The firms linked to the sector have also wholeheartedly endorsed the School, articulating this through the *Fundación de la Ingeniería Civil de Galicia* (Foundation of Civil Engineering of Galicia), source of resources and of support from the very early and difficult years of the School, up to the moment. Special mention should be made to the founder of the School, Prof. Fermín Navarrina Martínez, its first Head of the Department.

Apart from some relevant information about the degree and the School, the student will find in this guide the organisation, the syllabus and the basic assigned bibliography of every subject of the present Study Plan. This information has been included in this ECTS Information Package, with the aim that incoming foreign students entering this School, have a source which brings together all the relevant information for the development of the complete degree or exchange studies.

2. THE *ESCUELA DE INGENIEROS DE CAMINOS*

2.1. FACILITIES

The *Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos de La Coruña* is located at the entrance of the Elviña Campus. Inaugurated on 13th January 1994, it is a single building of 16,000 square metres separated into two wings, connected by a hall, which constitutes the access to the School. In this space are found the cafeteria and the auditorium, with a capacity for four hundred people.

The first wing houses on three floors the offices of the academic staff, the Delegation of the Foundation of Civil Engineering of Galicia, and the Administration and Head Offices.

Beyond the hall is found the second area of the building, composed equally of three floors. Along the central corridor of the basement floor are situated most of the laboratories of the School, i.e., Surveying, Highway Engineering, Harbours and Coasts, Environmental Engineering, Hydraulics and Hydrology, Materials Science, Geotechnology, Construction Engineering, Land Use Planning and Computer Aided Design. The laboratories occupy a total surface area of 2,000 square metres and have an exterior access for entrance and exit of materials.

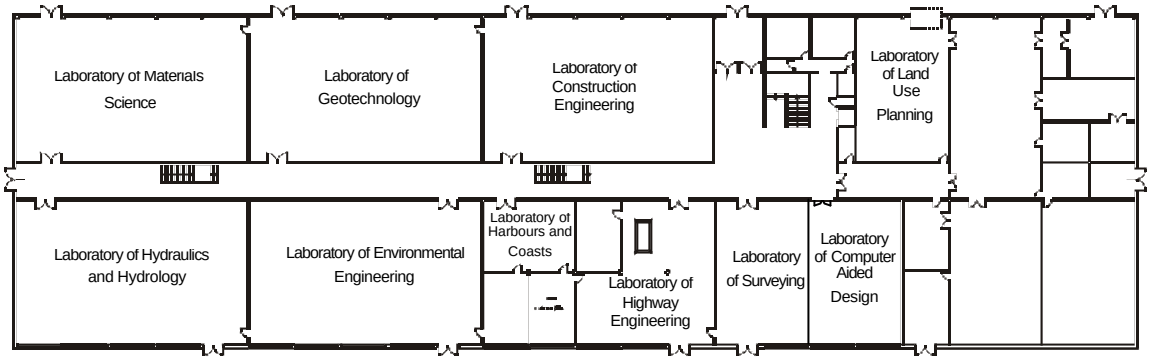
The intermediate floor, at the level of the main access point, houses the other laboratories of the School (Numeral Calculus, Structures Calculation, Physics and the Centre of Calculus); two *Salas de Grados* (Graduate´s Rooms), devoted to the presentation of Projects, Doctoral Theses, and the holding of conferences and technical courses, seminars, etc.; a Proyect Room, the End of Degree Proyects Room, the *Delegación de Estudiantes* (Students Union), the Photocopy Service and the Internet Room.

On the upper floor is found the Library, which allows some 100 people to work comfortably. On this floor are situated the School´s seven lecturing theatres, three with a capacity for 60 people, used for giving lectures in the Second and the Third Cycle of the Degree, and four with a capacity for 140 students. At this level is also found a Design Room which has a capacity for around 140 students.

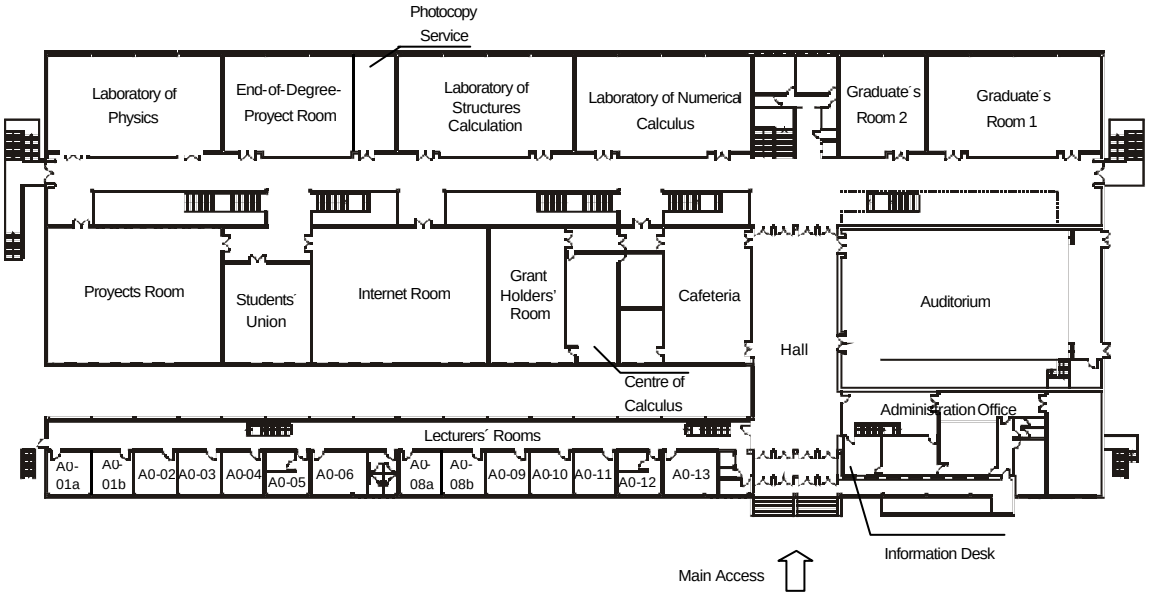
The adjacent building houses the CITEEC (*Centro de Innovación Tecnológica en Edificación e Ingeniería Civil*, Centre for Technological Innovation in Building and Civil Engineering). This institution depends directly on the University and is mainly devoted to the research related to the engineering and architecture disciplines. Nevertheless, the CITEEC is also used for teaching purposes, and some of the practical lectures of the Degree in Civil Engineering will take place in it.

On the following pages are found the plans of the four floors which the School has: Basement Floor, Ground Floor, First Floor and Second Floor.

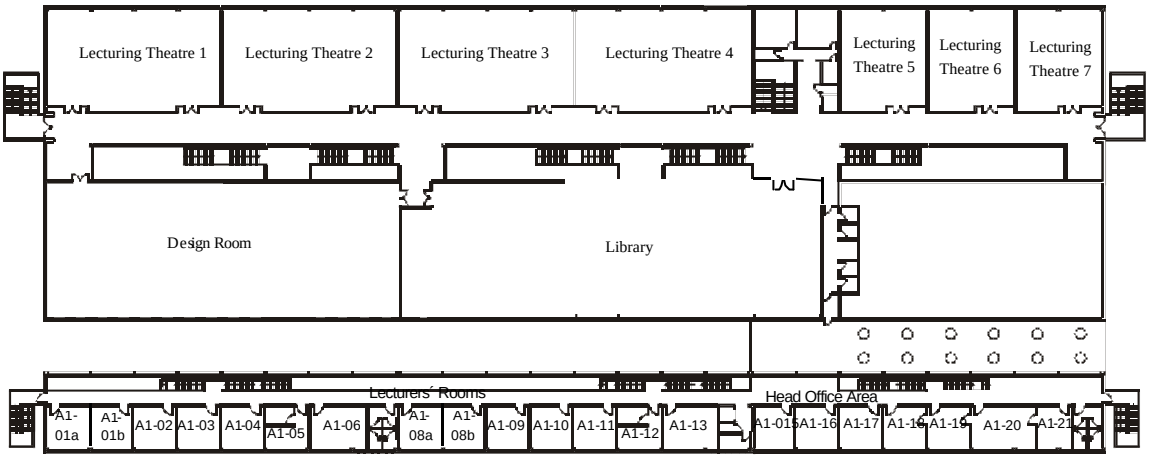
Basement Floor


Laboratory of Materials Science
Laboratory of Geotechnology
Laboratory of Construction Engineering
Laboratory of Land Use Planning
Laboratory of Hydraulics and Hydrology
Laboratory of Environmental Engineering
Laboratory of Harbours and Coasts
Laboratory of Highway Engineering
Laboratory of Surveying
Laboratory of Computer Aided Design

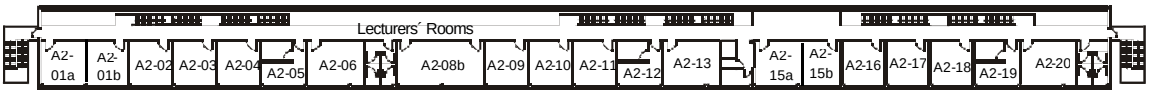
Ground Floor



First Floor



Second Floor



E.T.S. de Ingenieros de Caminos, Canales y Puertos
Campus de Elviña
15192 La Coruña
Spain
Tel.: 981 167000; Fax: 981 167170
E- mail: secdire@iccp.udc.es
Webpage: http:// www.udc.es/caminos

DIRECTOR (Head of the Department)
Miguel Rodríguez Bugarín
Tel: 981 167000 EXT 1439
bugarin@iccp.udc.es

ECTS Coordinator
Pablo Rodríguez-Vellando Fernández-Carvajal
Tel: 981 167000 EXT 1412
vellando@iccp.udc.es

2.2. STAFF

The *Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos de La Coruña* has a workforce which includes the lecturers assigned to the degree of *Ingeniería de Caminos, Canales y Puertos*, and the administration and services personnel, assigned to the School itself. On continuation is presented a relation of the personnel of the School grouped according to their field of activity or work group.

2.2.1. Academic Staff

The lecturers in the *Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos* are grouped in *Departamentos*. Within each department there are lecturers grouped together in accordance with the affinity of their lecturing and research topics.

CU: *Catedrático de Universidad* (University Professor)
TU: *Profesor Titular de Universidad* (Full University Lecturer)
TUI: *Profesor Titular de Universidad Interino* (Temporary Full University Lecturer)
TEU: *Profesor Titular de Escuela Universitaria* (Full University College Lecturer)
PMC: *Profesor de la Marina Civil* (Merchant Navy Lecturer)
PAU: *Profesor Asociado de Universidad* (Assistant University Lecturer)
TC: Full Time; TP: Part Time

Departamento: Tecnología de la Construcción **(Construction Technology)**
Area: *Ingeniería de la Construcción* (Construction Engineering)

Martínez Abella	Fernando	TU-TC
Herrador Barrios	Manuel	PAU-TC
Vázquez Herrero	Cristina	PAU-TC
Durán Fuentes	Manuel	PAU-TP
Fernández Garitaonandía	Antonio	PAU-TP
Orejón Pajares	José Antonio	PAU-TP
Vázquez Peña	Juan Ignacio	PAU-TP

Area: *Ingeniería del Terreno* (Earth Engineering)

Samper Calvete	F. Javier	CU-TC
Delgado Martín	Jordi	TU-TC
del Hoyo Fernández-Gago	Rodrigo	TU-TC
Juncosa Rivera	Ricardo	TUI-TC
Medina Rodríguez	Luis Esteban	TUI-TC
Padilla Benítez	Francisco	TUI-TC
Molinero Huguet	Jorge	PAU-TC
Montenegro Pérez	Luis	PAU-TC

Area: *Mecánica de Medios Continuos y Teoría de Estructuras* (Cotinuum Mechanics and Theory of Structures)

Hernández Ibáñez	Santiago	CU-TC
Perezzán Pardo	Juan Carlos	TUI-TC
Romera Rodríguez	Luis Esteban	TUI-TC
Fontán Pérez	Arturo N.	PAU-TC
Jurado Albarracín-Martinón	José Ángel	PAU-TC
Mosquera Martínez	Alejandro	PAU-TC
Peña González	Enrique	PAU-TC
González Meijide	José Antonio	PAU-TP

Departamento: Métodos Matemáticos y de Representación
(Mathematical and Representation Methods)

Area: *Ingeniería Cartográfica, Geodésica y Fotogrametría* (Cartography, Geodesy and Photogrammetry Engineering)

Álvarez García	Julia	PAU-TC
Hernández Ibáñez	Luis Antonio	PAU-TC
González del Río	Ángel	PAU-TP
López Blanco	Antonio	PAU-TP
Serantes Barbeito	José Antonio	PAU-TP
Solas Alados	José Miguel	PAU-TP

Area: *Ingeniería e Infraestructura de los Transportes* (Transport Infrastructures and Engineering)

Rodríguez Bugarín	Miguel D.	TU-TC
Pérez Pérez	Ignacio	TUI-TC
Novales Ordax	Margarita	PAU-TC
Orro Arcay	Alfonso	PAU-TC
Sánchez Tamayo	Pedro	PAU-TP

Area: *Ingeniería Hidráulica* (Hydraulic Engineering)

Acinas García	Juan Román	TU-TC
Puertas Agudo	Jerónimo	TU-TC
Iglesias Rodríguez	Gregorio	PAU-TC
Babio Arcay	Ricardo	PAU-TP

Area: *Matemática Aplicada* (Applied Mathematics)

Casteleiro Maldonado	Manuel	CU-TC
Navarrina Martínez	Fermín Luis	CU-TC
Colominas Ezponda	Ignasi	TU-TC
Martul Álvarez de Neyra	Ramón	TU-TC
Domínguez Pérez	Xabier Eduardo	PAU-TC
Fe Marqués	Jaime	PAU-TC
Gómez Calviño	Javier	PAU-TC
López Jato	Raquel	PAU-TC
Martínez Lage	Isabel	PAU-TC
Mosqueira Martínez	Gonzalo	PAU-TC
Rodríguez-Vellando Fernández-Carvajal	Pablo	PAU-TC

Area: *Tecnologías del Medio Ambiente* (Environmental Technologies)

Suárez López	Joaquín	TU-TC
Jácome Burgos	Alfredo	TUI-TC
Rodríguez Justo	Estrella	PAU-TC

Area: *Proyectos en la Ingeniería* (Projects in Engineering)

Bértolo Cadenas	Juan José	PAU-TP
García Cordovilla	César	PAU-TP

Departamento: Proyectos Arquitectónicos y Urbanismo
(Architectural Projects and Urbanism)

Area: *Urbanística y Ordenación del Territorio* (Urbanism and Land Planning)

Nárdiz Ortiz	Carlos	TU-TC
Creus Andrade	Juan José	PAU-TC
López González	Cándido Jaime	PAU-TC

Departamento: Energía y Propulsión Marina **(Energy and Maritime Propulsion)**

Area: *Ciencia de los Materiales e Ingeniería Metalúrgica* (Material Science and Metallurgical Engineering)

Toledano Prados	Mar	PAU-TC

Departamento: Ingeniería Industrial **(Industrial Engineering)**

Area: *Expresión Gráfica de la Ingeniería* (Graphic Design in Engineering)

Urrutia Lambarri	Jesús	PMC-TC

Departamento: *Economía Aplicada I* (Applied Ecomomics I)

Area: *Economía Aplicada (*Applied Economics)

Vasallo Rapela	Alejandro	PAU-TP

Departamento: *Filología Inglesa* (English Philology)

Area: *Filología Inglesa* (English Philology)

Dopico García	Alberto	TEU-TC

Departamento: Gallego-Portugués, Francés y Lingüística
(Galician-Portuguese, French and Linguistics)

Area*: Filología Francesa* (French Philology)

Regueiro Diehl	Mercedes	TEU-TC

***Departamento: Computación* (Computing Science)**

Area: *Ciencia de la Computación e Inteligencia Artificial* (Computing Science and Artificial Intelligence)

Moret Bonillo	Vicente	TU-TC

***Departamento: Composición* (Composition)**

Area: *Composición Arquitectónica* (Achitectural Composition)

Cerviño Lago	Josefina	PAU-TP

2.2.2. Non-Academic Staff

Administration and Students Office

Seijo García	Julia
Díaz Marqués	José Antonio

Financial Administration Office

de la Fuente Simes	Pilar

Information Office

Pan Lantes	Horacio
Casal García	María Jesús
Méndez Vázquez	María Esther
Rodríguez Martínez	Roberto

Library

Roel Vilas	Pilar
Sierra Quiroga	Carmen
Fernández López	José Felipe
Seoane Antelo	Juana

Secretary of the *Departamento de Métodos Matemáticos y de Representación*

Añón Teijido	José Luis

Secretary of the Head of the Department of Civil Engineering

García Filgueira	Ana María

Webmaster

Rodríguez Fernández	Alejandra

2.3. ROOMS and TELEPHONE NUMBERS

SURNAME	NAME	NUMBER	ROOM
Acinas García	Juan Román	1446	A0-06
Álvarez García	Julia	1448	A0-08b
Añon Teijido	José Luis	1419	A2-19
Babio Arcay	Ricardo	1444	A0-04
Balado González	Cristina	1455	A2-01b
Beade Pereda	Hector	1407	A2-08
Beneyto González-Baylin	Mª Carmen	1421	A1-01b
Bértolo Cadenas	Juan José	1428	A1-08b
Casal García	Mª Jesús	1400	A0-15
Casteleiro Maldonado	Manuel	1420	A2-20
Cerviño Lago	Josefina	1445	A0-05
Colominas Ezponda	Ignasi	1417	A2-17
Creus Andrade	Juan José	1401	A2-01ª
Dafonte Vázquez	Carlos	1466	B0-12
Delgado Martín	Jordi	1429	A1-09
Díaz Maques	José Antonio	1470	A0-16b
Domínguez Pérez	Xabier Eduardo	1418	A2-18
Dopico García	Alberto	1425	A1-05
Durán Fuentes	Manuel G.	1442	A0-01b
Fe Marqués	Jaime	1416	A2-16
Fernández Garitaonandía	Antonio	1442	A0-01b
Fernández López	Felipe	1460	B1-12
Fontán Pérez	Arturo Norberto	1410	A2-10
Fuente Simes	Pilar de la	1471	A0-16ª
García Cordovilla	César	1445	A0-05
García Fernández	Carmen	1421	A1-01b
García Filgueira	Ana	1439	A1-19
Gómez Calviño	Javier	1415	A2-15b
González del Río	Ángel	1447	A0-08ª
González Fonteboa	Mª Belén	1442	A0-01b
González Meijide	José Antonio	1426	A1-06
Grandío Chao	Guillermo	1445	A0-05
Hernández Ibáñez	Luis Antonio	1409	A2-09
Hernández Ibáñez	Santiago	1406	A2-06
Herrador Barrios	Manuel Francisco	1441	A0-02
Hoyo Fernández-Gago	Rodrigo del	1427	A1-08ª
Iglesias Rodríguez	Gregorio	1444	A0-04
Jácome Burgos	Alfredo	1422	A1-02
Juncosa Rivera	Ricardo	1431	A1-11
Jurado Albarracín-Martinón	José Ángel	1404	A2-04
Landeira Péreira	Mercedes	1435	A1-15
López Blanco	Antonio	1447	A0-08ª
López González	Candido Jaime	1401	A2-01ª
López Jato	Raquel	1415	A2-15b
Loscos Areoso	Pablo	1407	A2-08
Martínez Abella	Fernando	1443	A0-03
Martínez Lage	Isabel	1418	A2-18
Martul Alvarez de Neyra	Ramón	1411	A2-11
Medina Rodríguez	Luis Estebán	1424	A1-04
Melis Maynar	Manuel	1424	A1-04
Méndez Castro	Ana	5463	B0-11
Méndez Vázquez	Esther	1400	A0-15
Molina Burgos	Yudith	5430	BS-05
Molinero Huguet	Jorge	1423	A1-03
Montenegro Pérez	Luis	1425	A1-05

SURNAME	NAME	NUMBER	ROOM
Moret Bonillo	Vicente	1428	A1-08b
Mosqueira Martinez	Gonzalo	1416	A2-16b
Mosquera Martínez	Alejandro	1403	A2-03
Nardiz Ortiz	Carlos	1402	A2-02
Navarrina Martinez	Fermin Luis	1413	A2-13
Novales Ordax	Margarita	1452	A0-12
Orejon Pajares	Jose Antonio	1441	A0-02
Orro Arcay	Alfonso	1450	A0-10
Padilla Benitez	Francisco	1428	A1-08b
Pan Lantes	Horacio	1400	A0-15
Pérez Escacho	Marta	1408	A2-08
Peña González	Enrique	1426	A1-06
Pérez Pérez	Ignacio	1451	A0-11
Perezzán Pardo	Juan Carlos	1403	A2-03
Puertas Agudo	Jerónimo	1430	A1-10
Rodriguez-Vellando	Pablo	1412	A2-12
Recarey Buño	Mª José	5421	BS-03
Regueira Vigo	Mª Isabel	1405	A2-05
Regueiro Diehl	Mercedes	1425	A1-05
Rodríguez Bugarín	Miguel Domingo	1449	A0-09
Rodríguez Justo	Estrella	1422	A1-02
Rodríguez Martínez	Roberto	1400	A0-15
Roel Vilas	Pilar	1461	B1-11
Romera Rodríguez	Luis Esteban	1404	A2-04
Sáiz Gómez	Teresa	5430	BS-05
Samper Calvete	Francisco Javier	1433	A1-13
Sánchez Tamayo	Pedro	1450	A0-10
Seijo García	Julia	1472	A0-16b
Seoane Antelo	Juana	1460	B1-12
Serantes Barbeito	José Antonio	1447	A0-08ª
Sierra Quiroga	Carmen	1461	B1-11
Solas Alados	José Miguel	1448	A0-08b
Suárez López	Joaquín	1456	A1-01ª
Toledano Prados	Mar	1453	A0-13
Urrutia y Lambarri	Jesús Mª de	1409	A2-09
Valcarce Rodriguez	Iván	1408	A2-08
Varela García	Francisco Alberto	1474	BS-09ª
Vasallo Rapela	Alejandro	1401	A2-01ª
Vázquez González	Ana	5461	B0-11
Vázquez Herrero	Cristina	1457	A0-01ª
Vázquez Peña	Juan Ignacio	1441	A0-02
Vázquez Santana	Fernando	1421	A1-01b
Vieites Ponte	Carlos	1471	A0-16ª
Yang	Changbing	5460	B0-11
Zheng	Liange	5460	B0-11

	NUMBER	ROOM
Administration Office – Head of the Aministration	1472	A0-16b
Administration Office – Students Office	1470	A0-16b
Administration Office – Economics	1471	A0-16a
Network Room	1496	B0-13
Library - Desk	1460	B1-10
Library – Director	1461	B1-11
Library – Fax	5475	B1-11
Cafeteria	1468	B0-14
Centro de Cálculo (Center of Calculus)	1466	B0-12
Club Deportivo Caminos (Sports Society)	1480	B0-07
Club Fotográfico Caminos (Photography Society)	1469	B0-07

	NUMBER	ROOM
Club Informático de Caminos (Computing Society)	1481	B0-07
Information Office	1400	A0-15
Delegación de Estudiantes (Students Union)	1469	B0-07
Delegación de la Asociación de Ingenieros de Caminos Association of Civil Engineers Office	1463	A2-01b
Head Office – *Director* (Head of the Department)	1440	A1-20
Head Office – *Jefe deEstudios* (Director of Studies)	1498	A1-17
Head Office – Meeting room	1434	A1-22
Head Office – Secretary of the Head of the Department	1439	A1-19
Head Office – *Secretario Académico* (Academic Secretary)	1438	A1-18
Head Office – *Subdirector de Coordinación* (Vice-Director of Coordination)	1436	A1-16
Fax	1475	A0-15
Fundación de la Ingeniería Civil Foundation of Civil Engineering	1435	A1-15
Ingenieros sin Fronteras (Engineers without frontiers)	1479	B0-07
Laboratory of Structures Calculation	5453	B0-03
Laboratory of Numerical Calculus	5454	B0-04
Laboratory of Highway Engineering	5435	BS-06b
Laboratory of Materials Science	5410	BS-01
Laboratory of Physics	5451	B0-01
Laboratory of Computer Aided Design	5443	BS-07b
Laboratory of Hydraulics and Hydrology	5425	BS-04
Laboratory of Environmental Engineering	5430	BS-05
Laboratory of Construction Engineering	5420	BS-03
Laboratory of Geotechnology	5415	BS-02
Laboratory of Projects	5450	B1-17
Laboratory of Harbours and Coasts	5438	BS-06a
Laboratory of Surveying	5440	BS-07a
Meeting Room	1454	A0-22
Laboratory of Land Use Planning	1474	BS-09a
Photocopy Service	1497	B1-16

3. TEACHING ORGANIZATION

3.1. DEGREE IN CIVIL ENGINEERING (*INGENIERO DE CAMINOS, CANALES Y PUERTOS*)

3.1.1. Degree Syllabus (1991 Plan)

The current syllabus of the Degree in Civil Engineering (*Ingeniero de Caminos, Canales y Puertos*), was approved by the *Consejo de Universidades* (Council of Universities) on 27th September 1991. The aim of this plan is to form highly qualified engineers, with a solid scientific foundation, which permits life-long learning and a general perspective in the global ambit of Civil Engineering, not only in the purely technical aspects but also in those related with organisation and management aspects. Additionally, the large number of choices permits the student to design his or her own curriculum, intensifying their knowledge in a specific field.

This plan is made up of 420 'Spanish' credits (CC), which are equal to 4,200 teaching hours or 300 European ECTS credits (EC).

The degree is divided into two parts: the first two years make up the First Cycle, and the other three constitute the Second Cycle. There is also the possibility of gaining direct access to the second cycle from other degrees. Finally the so-called Third Cycle studies lead to the obtaining of the PhD Civil Engineer title (*Doctor Ingeniero de Caminos, Canales y Puertos*). All these three different cycles are taught within the School. The First Cycle adopts a fundamentally basic and formative character. The third course is contemplated as a transition of technical and scientific character towards the fundamental technical and technological aspects which are developed specifically during the fourth and fifth years.

On continuation a list of the compulsory subjects which the students must do obligatorily in each one of the courses is provided. Each subject is preceded by an identification code, the number of European Credits (EC) and 'Spanish' credits (CC). The key (A, C1, C2, OP1, OP2, LC) stands for the type and length of each of the courses as follows:

A = Compulsory annual
C1 = Compulsory, first four- month period
C2 = Compulsory, second four- month period
OP1 = Option, first four- month period
OP2 = Option, second four- month period
LC = Free Configuration

In the First and Second Cycle, the students must choose optional subjects until they have completed the number of credits indicated for each year. A list of the available 'Options' is also included.

In both cycles, the students must choose a certain number of 'Free Configuration' credits from among the list of courses provided by the different Faculties and Schools of the University, until they have completed the number of credits which is indicated.

Every single subject can be passed in the assessments of *June* and *September*. Passing any one of these two assessments will signify passing the whole subject. For those compulsory four- month- period subjects, the *June assessment* can be sat twice. Moreover, it is possible to pass the annual subjects by passing the two partial exams taking place in the February and June examination periods, in that case, the student does not need to sit the *June* and *September* assessments.

In some subjects, the submission of a coursework in due time will be also requested in order to pass the course.

The students, are offered the opportunity to follow a lesser number of options, if they carry out other types of activities for which they are awarded equivalent credits. In this sense, the *Academic Secretary* (Director of studies) will assign among the interested students, and according to their academic merits, some industry training period opportunities (with a minimum of 60 hours work in a month) in firms and public and private institutions related to Civil Engineering. This kind of industry placement during the summertime period will be equivalent to 4 EC. On the other hand, up to 12 EC are awarded for carrying out, presenting and defending a *Proyecto Técnico* (Technical Proyect). The *Proyecto Técnico* consists of a project, related to the definition in depth of the technological aspects of a civil engineering project, a study or report on an unconventional topic of the professional field, or a work related to engineering of development, or to pure research.

So as to obtain the degree, it will be necessary to pass all the subjects included in the table shown below, together with the presentation and defending of an End of Degree Project *(Proyecto Fin de Carrera)*.

3.1.2. First Cycle of the Degree

FIRST YEAR				
Code	EC	CC	Type	Course
101	10,5	15	A	Algebra
102	10,5	15	A	Calculus I
103	9	12	A	Technical Drawing
104	10,5	15	A	Applied Physics
105	9	12	A	Construction Materials
106	6,5	9	A	Surveying
	4	6	LC	Free Configuration
Total	60	84		

SECOND YEAR				
Code	EC	CC	Type	Course
201	9	12	A	Calculus II
202	9	12	A	Structures I
203	4,5	6	A	Metric and Descriptive Geometry
204	6,5	9	A	Hydraulics and Hydrology I
205	9	12	A	Geology and Introduction to Geotechnical Engineering
206	4,5	6	C1	Differential Geometry
207	4,5	6	C1	General and Applied to Public Works Economics
208	4,5	6	C2	Mechanics
209	4,5	6	C2	Transports and Land Use
	4	6	LC	Free Configuration
Total	60	81		

3.1.3. Second Cycle of the Degree

THIRD YEAR				
Code	EC	CC	Type	Course
301	8,5	12	A	Numerical Calculus
302	6,5	9	A	Statistics
303	8,5	12	A	Structures II
304	8,5	12	A	Geotechnical Engineering II
305	6	7,5	C1	Continuum Mechanics
306	4	6	C1	Calculus III
307	6	7,5	C2	Materials Science
308	4	6	C2	Hydraulics and Hydrology II
	4	6	OP	Options
	4	6	LC	Free Configuration
Total	60	84		

FOURTH YEAR				
Code	EC	CC	Type	Course
401	7	9	A	Reinforced and Prestressed Concrete I
402	7	9	A	Environmental Engineering
403	7	9	A	Harbours and Coasts
404	5,5	7,5	C1	Roads and Airports
405	4	6	C2	Electrical Engineering
406	5,5	7,5	C2	Steel Structures and Combined Construction
407	4	6	C1	Hydraulic Works
	12	18	OP	Options
	8	12	LC	Free Configuration
Total	60	84		

FIFTH YEAR				
Code	EC	CC	Type	Course
501	6	9	A	Projects and Works Organization and Management
502	4	6	C2	Building and Prefabrication
503	4	6	C1	Transport Engineering
504	2	3	C2	Legislation
505	4	6	C1	Regional and Urban Planning
506	4	6	C2	Business Organization and Management
507	2	3	C1	History of Civil Engineering
508	6	6		End of Degree Project
	20	30	OP	Options
	8	12	LC	Free Configuration
Total	60	87		

3.1.4. Options

OPTIONS				
Code	EC	CC	Type	Course
601	4	6	OP2	Dynamic Analysis of Structures
602	4	6	OP2	Special Foundations
603	4	6	OP1	Control and Regulation of Traffic
604	4	6	OP1	Structures III
605	4	6	OP1	Railways
606	4	6	OP1/2	Technical French
607	4	6	OP1	Reinforced and Prestressed Concrete II
608	4	6	OP1	Environmental Impact of Engineering Works
609	4	6	OP1	Maritime Engineering
610	4	6	OP2	Nuclear Engineering
611	4	6	OP2	Harbour Engineering
613	4	6	OP2	Geotechnical Engineering III
614	4	6	OP1/2	Technical English
617	4	6	OP1	Advanced Numerical Methods
620	4	6	OP2	Dams
621	4	6	OP2	Bridges I
622	4	6	OP1	Bridges II
624	4	6	OP2	Urban Services
625	4	6	OP1	Expert Systems
628	4	6	OP2	Urbanism II
630	4	6	OP2	Management and Operation of Harbours
631	4	6	OP1	Computer Aided Design and Visualization
632	4	6	OP2	Optimum Design of Structures
633	4	6	OP2	Railways Technical Operation
634	4	6	OP1	Underground Hydrology
635	4	6	OP2	History of Art
636	4	6	OP2	Engineering of Urban Sewage Systems
637	4	6	OP2	Materials and Constructive Systems
638	4	6	OP2	Rock Mechanics
639	4	6	OP2	Decision Taking in Engineering
640	4	6	OP1	Urbanism I
642	4	6	OP2	Roads and Airports II
653	4	6	OP2	Water Resources and Hydraulic Planning
657	4	6	OP1	Typology of Structures
658	4	6	OP1	Landscape in Engineering
659	4	6	OP2	Transport Planning
901	12	18	OP	Technical Project
	4	6	OP	Training Period

3.1.5. Direct access to Second Cycle for students who have finished the first cycle of other degrees

The overlapping of many of the subjects which are studied in the degrees in *Ingeniería de Caminos, Canales y Puertos* (Five or six-year degree in Civil Engineering), *Ingeniería Técnica de Obras Públicas* (Three-year degree in Civil Engineering), *Ingeniería de Minas* (Five or six-year degree in Mine Engineering) and *Ingeniería Técnica de Minas* (Three-year degree in Mine Engineering) has meant that traditionally students of these three degrees decide to continue their curricula in Civil Engineering.
The rules of access to the Second Cycle of the degree *Ingeniero de Caminos, Canales y Puertos* is regulated by the Order of 10th December 1993 of the Ministry of Education. In this order was established direct access to the Second Cycle without complements of education for the degrees of *Ingeniería Técnica de Obras Públicas* in the specialities of *Construcciones Civiles* (Civil Constructions), *Transportes y Servicios Urbanos* (Transports and Urban Services), and *Hidrología* (Hydrology).
For the degrees of *Ingeniero Técnico de Minas* with speciality in *Explotación de Minas* (Exploitation of Mines) and *Sondeos y Prospecciones Mineras* (Drilling and Prospecting Mining), and the students who have already passed the First Cycle of the degree in *Ingeniería de Minas* (Mine Engineering), the following complements of education are required:

ACCESS COMPLEMENTS FOR MINE ENGINEERS				
Code	EC	CC	Type	Course
203	4,5	6	A	Metric and Descriptive Geometry
204	6,5	9	A	Hydraulics and Hydrology I
209	4,5	6	C2	Transports and Land Use
				Second Cycle

3.1.6. Socrates and Double Degree Students

The *Escuela de Caminos*, will accept incoming Socrates students from the associated universities. These students will follow a choice of subjects agreed upon with their home University. It is recommended that these students follow a total of 30 or 60 EC, depending on the duration of their stay being a half-a-year term, or a whole-year period.
The *Escuela de Caminos* will also issue the Degree in *Ingeniería de Caminos, Canales y Puertos* to the students following and completing a Double Degree Programme. The particulars of these Double Degree Programmes will be specified in the corresponding Bilateral Agreement.

3.1.7. Information relative to each subject

On continuation is presented the information relative to subjects which lead to the degree of *Ingeniero de Caminos, Canales y Puertos*. In this list are included the options which are imparted throughout the academic year 2001/2002.

3.1.7.1. FIRST YEAR

Algebra

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Isabel Martínez Lage and Xabier Domínguez Pérez**
OTHER LECTURERS:	
YEAR:	**1st**
TYPE:	**Compulsory Annual**
CREDITS:	**5 hours per week. 15 CC. 10.5 EC**

Aims:

To know and to understand linear algebra in such a way that makes possible its use in other subjects.

Teaching Organization:

Lectures take up 5 hours per week, 3 of them theoretical and 2 of them practical.

Bibliography:

- *"Álgebra Lineal", Juan de Burgos, Editorial Mc-Graw-Hill, Madrid, 1993.*
- *"Álgebra vectorial y Tensorial", Fuente, Salete y Cruces, Editado por Servicio de Publicaciones de la E.T.S.I.C.C.P., Madrid, 1980.*
- *"Lecciones de Álgebra y Geometría", Alsina y Trillas, Editorial Gustavo-Gili, Barcelona, 1984.*
- *"Problemas de Álgebra", A. de la Villa, Editorial CLAGSA, Madrid, 1994.*
- *"Problemas de Álgebra" (Tomos 3, 6 y 7), Anzola, Caruncho y Pérez-Canales, Madrid, 1981.*
- *"Problemas de Estructuras Algebraicas Tensoriales", González de Posada, Madrid, 1971.*

Assessment:

Two partial examinations, and final exams in June and September. To pass "by course" , it is required to achieve a fixed mark in each partial examination.

Personal Tutorials:

In tutorial hours.

Additional Information:

Syllabus:

1. **BASIC OPERATIONAL CONCEPTS**
   Correspondences. Maps. Matrices. Operations with matrices. Elementary operations. Determinants. Minors. Adjoint and inverse matrices. Equivalence of matrices. Congruence of matrices. Similarity of matrices. Systems of linear equations.

2. **VECTOR SPACES**
   Vector spaces. Subspaces. Intersection of subspaces. Sum of subspaces. Linear combinations. Generating systems. Linear dependence and independence of vectors. Linearly independent sets. Basis. Dimension. Contravariant coordinates. Change of basis. Linear maps. Kernel and image. Endomorphisms. Eigenvalues. Diagonalization and triangularization by similarity. Multilinear maps. Bilinear maps. Quadratic forms. Conjugation. Diagonalization by congruence. Real quadratic forms. Duality. Tensorial product. Generalized tensorial powers. Homogeneous tensors. Tensoriality criteria. Algebra of homogeneous tensors. Symmetry and anti-symmetry of tensors.

3. **FINITE-DIMENSIONAL EUCLIDEAN VECTOR SPACES**
   Scalar product. Norm. Covariant coordinates. Reciprocal basis. Orthogonal vectors. Orthogonality of real functions. Orthogonal projection. Symmetric endomorphisms. Orthogonal transformations. The space of ordinary geometrical vectors. Wedge product. Mixed product.

4. **AFFINE SPACES**
   Affine space. Dimension. Affine basis. Frames. Affine varieties. Equations. Intersection and sum. Homogeneous coordinates. Points at infinity. Completed affine space. Euclidean affine space. Orthogonality. Distance. Affine transformations. Ordinary geometrical space.

5. **CONICS AND QUADRICS**
   General study of conics. Center. Asymptotical directions. Degenerate conics. Classification. Polarity. Diameters. Axis. Vertices. Involutions. Focus. Directrices. Eccentricity. Sheaves of conics. Ellipse. Hyperbola. Parabola. General study of quadrics. Center. Reduced equation. Degenerate quadrics. Classification. Polarity. Diametral planes. Diameters. Principal planes. Axis. Cones. Cylinders. Ellipsoids. Hyperboloids. Paraboloids.

Calculus I

DEPARTMENT: **Mathematical and Representation Methods**
LECTURER IN CHARGE: **Jaime Fe Marqués**
OTHER LECTURERS: **Javier Gómez Calviño, Raquel López Jato and Pablo Rodríguez-Vellando**

YEAR: **1st**
TYPE: **Compulsory Annual**
CREDITS: **5 hours per week. 15 CC. 10.5 EC**

Aims:

To provide the students with a solid basis for the resolving of the mathematical problems which they are going to meet during their studies or in the professional field.

Teaching Organization:

Every week, two theoretical and three practical sessions are imparted. During the latter, previously proposed problems are solved. One of the practical sessions is devoted to the resolution of integrals. A collection of examination problems, integrals and theoretical questions is at the students disposal.

Bibliography:

- *"Cálculo Infinitesimal. Una y varias variables", Granero, F., Mc Graw-Hill, Madrid, 96.*
- *"Cálculo Infinitesimal de una variable", Burgos, J., Ed. Mc Graw-Hill, Madrid, 1994.*
- *"Introducción al Análisis Matemático", Ortega, J.M., U. A. de Barcelona, 1990.*
- *"Cálculo I. Teoría y problemas de Análisis Matemático en una variable", García, A. y otros, Ed. CLAGSA, Madrid, 1993.*
- *"Cálculo I. Teoría y problemas de funciones de varias variables",García, A. y otros, Ed. CLAGSA, Madrid, 1996.*
- *"Ejercicios y problemas de Cálculo", Granero, F., Ed. Tébar Flores, Albacete, 1991.*
- *"Cálculo integral. Metodología y problemas", Coquillat, F., Ed. T. Flores, Albacete, 1980.*
- *"Problemas y ejercicios de análisis matemático", Demidovich, B., Ed. Paraninfo, Madrid.*
- *"Problemas de Cálculo infinitesimal e integral", Bronte, R., Madrid, 1977.*
- *"Fórmulas y tablas de matemática aplicada", Spiegel, y Abellanas, Ed. Mac Graw-Hill.*

Assessment:

Besides the June and September examinations, two partial exams are held. In the partial exams, an average mark of 5 out of 10 , with a minimum of 3.5 in each, is necessary to pass. In the June and September examinations a mark of 5 out of 10 is necessary to pass. All the subjects given from the beginning of the course until the moment of the examination form part of the examination.

Personal Tutorials:

During tutorial hours, which are announced at the beginning of the course, or at another time previously agreed with the lecturer.

Additional Information:

Syllabus:

1.THE REAL NUMBER

The concept of number: successive extensions. Structure of $\mathbb{Q}$. Sequences in $\mathbb{Q}$. Proprieties of $\mathbb{Q}$. The real number: definition, proprieties and operations.

2.METRIC AND TOPOLOGICAL SPACES.

Metrical space. Definition and proprieties. Open and closed balls. Different types of points (closure, accumulation, isolated, interior, exterior, boundary) and sets (open, closed, compact, dense). Neighborhood. Topological space. Topology in $\mathbb{R}$. Heine-Borel-Lebesgue Theorem. Bolzano-Weiestrass Theorem.

3.FUNCTIONS IN $\mathbb{R}$.

Functional space of the numerical functions: domain, range, extreme values, proprieties. Limit of a function: one-sided limits; Cauchy convergence test; proprieties; operations; infinite and infinitesimal. Continuous functions: discontinuities; one-sided continuity; operations; composition of functions; continuity in a metrical space; theorems on continuous functions; uniform continuity. Sequences of functions: metrical space of the bounded functions; uniform and non-uniform convergence; sequences of continuous functions. Series of functions: uniform and non-uniform convergence; Cauchy's convergence test; comparison with a series of numbers; continuity; integration; differentiation; power series; Cauchy-Hadamard Theorem; Abel Theorem. Differentiable functions: derivative and differential; differentiation as a lineal application; operations; the chain rule; derivatives of elementary functions; derivative of the inverse function; mean value Theorems; rules of L' Hospital; successive differentiation; Taylor and McLaurin series. Representation of curves: cartesian and polar co-ordinates. Parametric representation.

4. INTEGRATION.

Antiderivative of a function. Riemann Integral. Mean value Theorems. Fundamental Theorem of Calculus. Riemann sums. Improper integrals. Determination of antiderivatives: integration formulas; integration by parts; reduction formulas; integration of trigonometric, rational, irrational, exponential, logaritmic and hyperbolic functions. Determination of areas, volumes and arclengths; surfaces of revolution. Double integrals, triple integrals.

5. VECTORIAL FUNCTIONS.

Generalization of concepts: limit, continuity, differentiability. Vector function of a real variable. Real function of a vector variable. Vector function of a vector variable. Composition of functions. The chain rule. Higher derivatives. Mixed partial derivatives. Higher differentials. Taylor series. Relative maxima and minima. Implicit function. Inverse function. Constrained maxima and minima.

6. COMPLEX NUMBERS.

Definition and basic operations. Binomial and trigonometrical representation of a complex number. Conjugate and inverse of a complex number. Euler formula. Power, root and logarithm of a complex number. Hyperbolic and trigonometric functions in $\mathbb{C}$.

7. SEQUENCES IN $\mathbb{R}$.

Sequences in metrical spaces: definition, limit of a sequence, types of sequences. Monotonic sequences. Operation with limits. Indeterminate expressions. Infinite and infinitesimal. Convergence tests. Determination of limits.

8. SERIES IN $\mathbb{R}$.

Definition and properties. General convergence tests. Convergence tests for series of positive terms. Series of positive and negative terms. Absolute convergence and conditional convergence. Riemann Theorem. Dirichlet theorem. Alternating series. Leibnitz Theorem. Determination of the sum of a series.

Technical Drawing

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Julia Álvarez García**
OTHER LECTURERS:	
YEAR:	**1st**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 12 CC. 9 EC.**

Aims:

Acquisition and development of spatial vision and the techniques to be reflected in the plan. Acquiring the layout techniques of lineal and platform works. Applying the knowledge of Technical Drawing to the sketching and cubic measurement of the pieces related to Public Works, for its knowledge, understanding and familiarization, carrying it out with the necessary rapidity and quality.

Teaching Organization:

The lectures are divided into 2 theoretical sessions per week and another two sessions of practical lectures classes. The topics of the program are organized in two parts: an A part of Theoretical Technical Drawing and a B part of Practical Technical Drawing.

Bibliography:

- *"Geometría Descriptiva", Izquierdo Asensi, F., Editorial Dossat, Madrid, 1979..*
- *"Geometría Descriptiva", Leighton Wellman, B., Editorial Reverte, Barcelona 1987..*
- *"Geometría Descriptiva. Sistema Acotado", Martín de Morejón, L., E.U.A.T de Madrid, Barcelona, 1985..*
- *"Dibujo Técnico de Ingeniería", Campos Asenjo, J., Ediciones Campos, Madrid, 1965.*
- *"Dibujo Técnico. Introducción a los Sistemas de Representación", Palencia, J., E.T.S.I.C.C.P., Madrid, 1986.*
- *"Geometría Descriptiva", Rodríguez Abajo, F.J., Editorial Marfil, Alcoy, 1986..*

Assessment:

There will be two partial exams, and the final exams corresponding to the exam period of June and September.

Personal Tutorials:

At the end of the class sessions (short consultancies) and in a timetable to be established with the lecturers (long consultancies).

Additional Information:

Elementary knowledge of volume calculation is required.

Syllabus : A. Theory

1. INTRODUCTION TO THE CONCEPT OF DESCRIPTIVE GEOMETRY.
Aim of Descriptive Geometry. Projections: central or conical and parallel or cylindrical. Systems of representation. Conventions. Scales. Normalization of the paper.

2. GENERALITIES OF DIHEDRAL SYSTEM.
Concept, advantages and inconveniences of the system. European and American systems. Affinity among projections. Changes of plane, successive auxiliary views. Analysis of visibility. Sections. Boundedness.

3. GENERALITIES OF THE A CONTOUR SYSTEM.
Concept, advantages and inconveniences. Topographical surfaces : contours, Analysis and interpretation of contours. Elemental forms of terrain.

4. GENERALITIES OF THE AXONOMETRIC SYSTEM.
Concepts, advantages and inconveniences. Units or axonometric scales, coefficients of reduction. Classification of the axonometries. Moving from a dihedral system to an axonometric system. Direct construction of axonometric perspectives by double change of plane. Oblique axonometry. Isometric projection. Isometric Projection.

5. GENERALITIES OF CENTRAL PROJECTION.
The Conical System: concepts, advantages and inconveniences. Concept of linear perspective. Representation of the point. Representation of a straight line. Particular positions of the straight line. Classification of the linear perspectives. Perspectives of a plane of vertical panel. Construction of the oblique linear perspective of plane and vertical panel.

6. THE POINT AND THE STRAIGHT LINE IN PARALLEL PROJECTION
Representation of the point and the straight line. Particular positions of the straight line. Segments in real longitude. Real magnitude of oblique segments in a dihedral system. Course, angle, degree and module of a straight line. Scaling of straight lines.

7. REPRESENTATION OF THE PLANE. FLAT FIGURES.
Representation of the plane. Particular positions. Figures in real magnitude. Points and straight lines on the plane. Principal straight lines, of maximum angle and maximum inclination. Conversion of a plane in a projection plane. Representation of flat figures.

8. INTERSECTIONS
Improper intersection in dihedral and axonometric systems. Parallelism and intersection between straight lines, between planes and between a straight line and a plane. Conditions of parallelism.

9. INTERSECTION IN A CONTOUR SYSTEM.
Intersection between straight lines, between planes and between a straight line and a plane. Intersection of topographical surfaces. Resolution of roofs, half slope terraces. Layout of pits and embankments. Layout of alignments. Scaling of slopes.

10. ELEMENTS OF THE THEORY OF SHADOWS
Basic concepts: object and conventions of the drawing of shadows. Solar coordinates. Shadow of a point, of a vertical segment, of any segment, of elemental polyhedrons and of the circumference. Own shadow and cast of cones and cylinders.

B. Practical Lectures

1. STUDY OF FORMS
(Loose pieces). Drawing of pieces. Drawing of projections. Calculation of volumes and rotations.

2. MEASURING AND CONSTRUCTION DETAILS

(Reduced plans of real projects). Bridges: abutments, columns and panels; corridors; nozzles, chests; etc. General perspective of works and various exercises on structural elements of Civil Works.

Applied Physics

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Enrique Peña González**
OTHER LECTURERS:	**Arturo N. Fontán Pérez**
YEAR:	**1st**
TYPE:	**Compulsory Annual**
CREDITS:	**5 hours per week. 15 CC. 10.5 EC**

Aims:

To supply the student with the fundamental knowledge of Applied Physics, in order to face subjects of the next courses, and to solve basic problems of physics in civil engineering.

Teaching Organization:

In general there will be three hours per week of theory lectures and two hours per week of practical ones. Laboratory practical lectures will be also held in small groups.

Bibliography:

- *"Física (2 Vol.)", Serway, R. A., Mc Graw-Hill Interamericana Editores, Méjico, 1997 (fourth edition).*
- *"Física para la ciencia y la tecnología (2 Vol.)", Tipler, Paul A., Editorial Reverté. España 1999 (fourth edition).*
- *"Física Universitaria (2 Vol..)", Sears, F.W., Zemansky M.W., Young H.P., Freedman R.A., Addison Wesley Longman de México. México 1999 (ninth edition).*
- *"Mecánica vectorial para ingenieros (2 Vol.)", Beer,F.P. y Johnston,E.R., Mc Graw-Hill Interamericana de España, Madrid, 1997 (sixth edition).*
- *"Física, Vol.1: Mecánica, Vol.2: Campos y Ondas", Alonso, M. y Finn, E.J., Addison-Wesley Iberoamericana, Estados Unidos 1987*
- *"Curso de termodinámica", Aguilar,J., Alhambra-Longman, Madrid, 1998.*
- *"Termodinámica". Wark K. , D.E. Richards. Mc Graw-Hill Interamericana de España. Madrid 2001 (sixth edition).*

Assessment:

There will be two assessment examinations covering part of the course and two final examinations in June and September. In order to pass it is necessary to obtain a minimum mark in both partial exams and also to carry out the laboratory practical lesctures.

Personal Tutorials:

The lecturers will post their tutorial hours at the beginning of the academic year.

Additional Information:

Syllabus:

1. **VECTOR SYSTEMS**
   Polar moment. Axial moment. Invariants. Central axis. Equivalence and reduction.

2. **PARTICLE MECHANICS**
   Kinematics of particle: Velocity and acceleration vectors. Dynamics of particle. Newton Laws; Work; Power; Kinetic energy; Work-kinetic energy theorem; Conservative fields; Potential energy; Law of Conservation of mechanical energy; Friction; Momentum and angular momentum; Central forces; Inertial reference frames and non inertial reference frames.

3. **GEOMETRY OF MASS POINT PARTICLES**
   Centre of gravity and mass. Centroid. Pappus-Guldin theorems. Moments of inertia. Steiner theorem. Moments and products of inertia in plane areas. Mohr´s circle.

4. **MECHANICS OF RIGID BODIES**
   Kinematics of rigid bodies; Velocity fields; Acceleration fields. Dynamics of rigid bodies: Newton´s Law; Energetic concepts; Momentum and angular momentum; Collisions; Vibrations. Static equilibrium.

5. **ELASTICITY**
   Stress. Equilibrium. Strain. Compatibility. Hooke´s Law. Tensile and compressive force. Shear force. Elastic energy.

6. **FLUID MECHANICS**
   Fluids. Pressure. Eulerian equation. Fluid static: Pascal and Archimidean principles; Forces and moments in submerged surfaces and volumes. Fluid dynamics: Continuity equation; Bernoulli´s equation; Impulse principle; Losses and gains of energy; Viscosity; Reynolds number; Laminar regime: Poiseuille and Stokes´s laws; Turbulent regime: resistance, buoyancy and Magnus effect.

7. **THERMODYNAMICS**
   Thermal properties of materials: temperature; equation of state; Ideal gasses; Real gasses; Thermometry; Dilatation; Calorimetry. Fist Law of Thermodynamics: Internal energy; Specific heats; Reversible transformations of an ideal gas; Adiabatic irreversible expansion of a gas. Second Law of Thermodynamics: Kelvin´s statement of the second law of thermodynamics; Clausius´s statement; Thermodynamic cycles of ideal gasses; Entropy; Equilibrium between phases: Phases rule of Gibbs; Surfaces of state in real substances; Clapeyron-Clausius equation; Superficial phases: surface tension and capillarity.

8. **WAVE PHENOMENON**
   Concept of waves. Harmonic waves. Standing waves: eigenfrequency. Huyghens statement. Reflection and refraction. Interference of waves with two sources, N sources and reflection in thin sheets. Fraunhofer diffraction in one rectangular and circular slit. Resolving power. Rayleigh´s criterion. Fraunhofer diffraction in two slits. Fraunhofer diffraction in N slits. Diffraction networks.

9. **ELECTROMAGNETIC INTERACTIONS**
   Electrostatic: Electrostatic field in vacuum; Coulomb´s Law; Gauss´s Law; Electrostatic field at conductor surfaces; Capacitors; Electrostatic field in dielectrics. Magnetostatics: Electromagnetic force; Motion of point charges; Motion of electric circuits; Magnetic field in vacuum; Biot-Savart´s Law; Ampere´s Law; Magnetism in matter. Electromagnetism: electromagnetic inductance; Faraday´s Law; Self-inductance; Mutual inductance.

Construction Materials

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Manuel F. Herrador Barrios**
OTHER LECTURERS:	**José A. Orejón Pajares, Juan I. Vázquez Peña**
YEAR:	**1st**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 9 EC**

Aims:

The course is designed to give theoretical and practical knowledge of physical, chemical, mechanical and technological properties of those materia ls most commonly used in Civil Engineering and thus learn how to use them correctly.

Teaching Organization:

Teaching is divided into theoretical lectures, and practical lectures with application of the theory and laboratory sessions. Guided visits to factories, laboratories and worksites related to the course will take place during the term.

Bibliography:

- *"Materiales de Construcción", Camuñas, A., Guadiana de Publicaciones, Madrid, 1974.*
- *"El Cemento Portland y otros aglomerantes", Gomá, F., Editores Técnicos Asociados, Barcelona, 1979.*
- *"Hormigón", Fernández, M., Serv. de Publicaciones R.O.P. E.T.S.I. Caminos, Madrid, 1991.*
- *"Materiales Metálicos de Construcción", Alaman, A., Serv. de Publicaciones R.O.P. E.T.S.I. Caminos, Madrid, 1990.*
- *"Materiales Bituminosos ", Fernández, M., Serv. de Publicaciones R.O.P. E.T.S.I. Caminos, Madrid, 1990.*
- *Lecture notes*

Assessment:

Two assessment tests will be provided. Each test is divided in a series of blocks covering different contents, and a minimum grade may be required in each of them. A minimum of 4 out of 10 in each test and an average of 5 out of 10 must be obtained to pass. Students failing on the partial test scheme may take a final exam covering the whole subject in June and September; passing requirements will be the same as in partial tests. In both cases, the full cycle of laboratory sessions must have been accomplished.

Personal Tutorials:

To be posted at the beginning of term.

Additional Information:

Syllabus:

1. **GENERAL PROPERTIES OF MATERIALS**
   Matter, state and structure. Organoleptic properties. Physical properties. Mechanical properties. Chemical properties. Durability.

2. **NATURAL ROCKS**
   Origin of rocks. Classification and properties. Testing. Extraction and preparation. Use in construction. Quarries. Rock works.

3. **CERAMIC MATERIALS**
   Ceramic materials: History. Raw materials and manufacturing. Use in construction. Properties and testing.

4. **PLASTERS**
   Manufacturing. Types. Properties. Testing. Constructive use of plasters.

5. **LIME**
   Manufacturing. Types. Properties. Testing. Constructive use of lime.

6. **CEMENTS**
   History and classification. Raw materials and production process. Chemical composition of Portland cements, clinker and potential composition. Cement types. Hydration. Structure of hardened cement paste. Properties and testing. Admixtures.

7. **CONCRETE**
   Introduction. Aggregates and grading. Properties of fresh concrete. Additives. Mix design: Fuller, Bolomey, Faury, ACI, de la Peña. Mixing, handling and placing. Joints. Curing. Properties of hardened concrete. Drying shrinkage. Resistance. Static and dynamic fatigue. Stress – strain diagram. Modulus of elasticity. Creep. Testing. Attacks. Reinforcement corrosion. Durability.

8. **BITUMINOUS MATERIALS**
   History. Classification. Composition. Production. Bitumen, tar and bituminous emulsions. Properties and testing. Codes, specifications and classifications. Use in construction: road pavements, waterproofing. Durability.

9. **METALLIC MATERIALS**
   General properties. Testing. Metallography and structure. Equilibrium systems, phase rule. Oxidation and corrosion. Iron and steel industry. Cast iron. Blast furnace. Steel. Casting refinement. Converters and electric furnaces. Iron and steel products. Thermic treatment. Non-ferrous materials. Aluminum: production, properties and usage. Metal working: forging, rolling, pulltruding, covering, molding, welding, mechanizing. Iron and steel products in construction: structures, railways, reinforcing, prestressing, pipelines.

10. **POLYMERS**
    Composition and typology. Production. Mechanical, electrical, optical and thermal properties. Chemical resistance. Shaping processes. Foams. Use in construction.

Surveying

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Antonio López Blanco**
OTHER LECTURERS:	**Ángel González del Río and José A. Serantes Barbeito**
YEAR:	**1st**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 6.5 EC.**

Aims:

To acquire the set of essential techniques to obtain measurements, form, plans, established layouts, to find geometries on the terrain or control movements of structures or land works.

Teaching Organization:

During 3 hours a week the theoretical lectures are provided and the practical exercises previously set are resolved. In the facilities of the School the students must carry out a series of field and studio practices, in order to achieve a full training in the topic. At the same time they carry out visits to cartographic production centres.

Bibliography:

- *"Introducción a la Topografía", Ferrer Torío, R. y Piña Patón, B., S Publicaciones E.T.S.IC.C.P.,Santander 1991.*
- *"Instrumentos Topográficos", Ferrer Torío, R. y Piña Patón B., S. Publicaciones E.T.S.I.C.C.P., Santander*
- *"Metodologías Topográficas", Ferrer Torío, R. y Piña Patón, B., S. Publicaciones E.T.S.I.C.C.P., Santander,1991.*
- *"Lectura de Mapas" Vázquez Maure, F. y Martín López, J.*
- *"Topografía General y Aplicada", Domínguez García- Tejero, F., Editorial Dossat.*
- *"Geodesia y Cartografía Matemática", Martín Assín, F..*
- *"Topografía" Chueca Pazos, M., Editorial Dossat.*
- *" Topografía y Replanteos", Martín Morejón, L., Editorial Romargraf.*
- *"Métodos Topográficos", Ojeda Ruiz, J.L.*

Assessment:

To pass it is necessary to have submitted and to pass the course projects. Two assessment exams are held besides the final exams of June and September. To pass the course it is necessary to obtain a minimum mark in each partial exam, and the course projects and the field and studio practices will be taken into account.

Personal Tutorials:

During working hours.

Additional Information:

Syllabus:

1. **GENERAL INTRODUCTION**
   Definition of scenes and basic contents: Surveying and geodesy, referential framing, conventional relief modelization, reading of maps and plans, interpretation of the photographs. Theory of errors applied to Surveying: necessity and limits of its study, error in direct measurement, the error as random, variable, observations with a different weight.

2. **TOPOGRAPHIC INSTRUMENTS**
   Angular measuring: general description of a goniometer, the optic theodolite, the compass, the electronic theodolite, errors in angular measures. Measuring by statistical methods, indirect measuring by electromagnetic methods, total topographic stations. Measuring heights: Introduction to altrimetric study, correction by sphericality and refraction, errors in indirect leveling, the bubble errors in geometric leveling, forms of work with the bubble.

3. **TOPOGRAPHICAL METHODOLOGIES**
   Introduction: necessity of its establishment, elemental field and studio techniques, principal methodologies. Methods based on the use of topographic stations: previous concepts and objectives, planimetric determinations, altimetric determinations. Methods based on the use of the tachometer: previous concepts and objectives, planimetric determinations, altimetric determinations. Methods based on the exclusive use of the theodolite: direct intersection, inverse intersection, triangulation. Geometric leveling: Introduction methods, geometric precision leveling. Classical topographic surveying: primitive, modern. Other methodologies: distanciometry , intersection of distances, trilateration.

4. **MAPPING**
   Optic and photographic elements, geometry of the photographic areas. General method, apparatus of restitution. Project using aircraft. Economic assessment. Performance.

5. **SURVEYING APPLIED TO ROAD ENGINEERING**
   Introduction. Geometry in ground plan, straight alignment and circular alignment. The clotoid. Geometry of elevation.

6. **GEODESY AND CARTOGRAPHY**
   Introduction. Ellipsoid of approximation. Generic treatment of the distance taken in the field: meteorological corrections, reduction of the distances to the ellipsoid. U.T.M. projection: approach, specific aspects of the projection. Defined point in geodesic coordinates: calculation of U.T.M coordinates, convergence of meridians and coefficient of lineal warping, application, other expression. Defining dots in U.T.M coordinates: calculation of geodesic coordinates, convergence of meridians and coefficient of lineal warping, applications, other expressions.

7. **ASTRONOMY**
   Notions and basic definitions.

3.1.7.2. SECOND YEAR

Calculus II

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Pablo Rguez-Vellando Fdez-Carvajal and Ignasi Colominas Ezponda**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 9 EC.**

Aims:

To know, to understand and to apply the analytical methods that allow for the resolution of Ordinary Differential Equations. To acquire the basic knowledge in the use of computers and FORTRAN programming.

Teaching Organization:

The theoretical lectures are carried out together with the resolving of some examples and practical problems, which have been previously posed. A FORTRAN code should be written as a coursework. This coursework can be elaborated making use of the computer facilities provided by the School.

Bibliography:

- *"Problemas de Ecuaciones Diferenciales Ordinarias", Kiseliov A., Krasnov M. y Makarenko G.; Mir, 1979.*
- *"Ecuaciones Diferenciales Aplicadas", Spiegel M.R.; Prentice-Hall, 1983.*
- *"Advanced Engineering Mathematics (Sixth Edition)", Kreyszig E.; J. Wiley S., 1988.*
- *"Ecuaciones Diferenciales. Problemas Lineales y Aplicaciones", Marcellán F., Casasús L. y Zarzo A.; Mc Graw-Hill, 1990.*
- *"Ecuaciones Diferenciales (Segunda Edición)", Simmons G.F.; Mc Graw-Hill, 1993.*
- *"Ecuaciones Diferenciales Elementales y Problemas con Condiciones en la Frontera (Tercera Edición)", Edwards C.H., and Penney D.; Prentice Hall, 1994.*
- *"FORTRAN 77 Programming. With an Introduction to the FORTRAN 90 Standard. (Second Edition)", Ellis T.M.R.; Addison-Wesley, 1990.*

Assessment:

So as to be able to pass the subject, it is compulsory to have carried out and passed the coursework. Two partial exams will be held, apart from those held in June and September, covering the whole contents of the subject. So as to pass 'by course', a minimum mark is required in each of the assessment exams. The marks obtained in the coursework and the submissions set over the whole length of the course will also be taken into account.

Personal Tutorials:

In working hours

Additional Information:

An elementary knowledge of Algebra and Calculus is required.

Syllabus:

1. FIRST ORDER DIFFERENTIAL EQUATIONS

Introduction. Existence and uniqueness of solutions. Cauchy´s problem. Separable differential equations. Homogeneous equations and reduction to homogeneous equations. Exact differential equations: integrating factor. Linear differential equations. Bernouilli equation and Ricatti equation. Equations unsolved in the derivative. Lagrange equation and Clairaut equation: singular solutions. Trajectory problems. Variational calculus. Application problems.

2. HIGHER ORDER DIFFERENTIAL EQUATIONS

Second order differential equations: theorem of existence and uniqueness of solutions; homogeneous and non-homogeneous equations; general solution to constant and non-constant coefficient homogeneous equations; obtaining of a particular solution of non-homogeneous equations: method of undetermined coefficients and method of variation of parameters; application to some mechanical and electrical oscillation problems. Higher order differential equations: theorem of existence and uniqueness of solutions; reduction of order; solution to the homogeneous equation; particular solutions; method of variation of parameters; operational calculus technique: resolution of linear differential equations of n order and constant coefficients.

3. SYSTEMS OF DIFFERENTIAL EQUATIONS

Theorem of existence and uniqueness of systems of differential equations. Reduction of the system of equations to a single equation of n-order. Integration of constant coefficient linear equations. Applications.

4. LAPLACE TRANSFORM

Basic concepts. Definition of Laplace transformation of a function: conditions for existence of transform and convergence abscise. Inverse Laplace transform. Laplace transform properties: changes in scale, *s*-shifting and *t*-shifting. Transforms of the derivative, the *n*-th derivative and the integral functions. Transformation of periodic functions. Convolution of functions. Application problems.

5. POWER SERIES RESOLUTION OF DIFFERENTIAL EQUATIONS

Introduction and basic concepts. Resolution of first order differential equations by using power series. Second order linear differential equations with regular points (Legendre equation) and with singular points: Frobenius series (Bessel, Hermite, Laguerre, Chebyshev and Hypergeometric Gauss equations). Orthogonal functions. Introduction to problems with eigenvalues and eigenfunctions: Sturm-Liouville problem. Orthogonality of the Legendre, Bessel, Hermite, Laguerre and Chebyshev equations. Application problems.

6. FOURIER SERIES

Orthogonal series of functions: generalised Fourier series. Transformation of periodic functions into their Fourier series expansion: Euler formulae and Fourier coefficients; convergence of Fourier series. Transformation of a function into even and odd functions and expansion of functions from arbitrary intervals. Resolution of differential equations using a Fourier series transformation. Definition and properties of the Fourier integral of a function; integral transformation sine and cosine of Fourier; complex transformation of the Fourier integral and direct and inverse transforms of Fourier.

7. COMPUTERS AND FORTRAN PROGRAMMING

Concept and types of computers: analogical and digital. FORTRAN programming: origins and evolution; phases of development and general organisation of a FORTRAN code; the FORTRAN language. Programming and use of computers: basic concepts, general rules of programming and structured programming.

Structures I

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Juan Carlos Perezzan Pardo**
OTHER LECTURERS:	**José Antonio González Meijide**
YEAR:	**2nd**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 9 EC.**

Aims:

To develop the elemental analysis of structures, studying the most usual typologies in Civil Engineering. To understand how the characteristics of the structures influence its behavior.

Teaching Organization:

Four hours per week lessons, two theoretical and two practical ones. Where problems given before are resolved. Most of these problems belong to exams previously given, which allows the student to know his or her level of knowledge of the subject.

Bibliography:

- *"Análisis lineal y no lineal de estructuras de barras", Hernández Ibáñez, S., E.T.S.I. Caminos, Canales y Puertos, Universidad de La Coruña.*
- *"Teoría de las Estructuras", Timoshenko, S.P., Young, D.H., Ed. Urmo, Bilbao, 1981.*
- *"Structures", Schodek, Daniel L., Prentice-Hall, New Jersey, 1980.*
- *"Elementary Structural Analysis, 4h ed.", Utku, S., Norris, C. H., Wilbur, J.B., McGraw Hill, New Jersey, 1991.*
- *"Razón y ser de los tipos estructurales",Torroja, E, C.S.I.C, Instituto Eduardo Torroja, Madrid, 1984*
- *"Elasticidad 2ª. ed.", Ortiz Berrocal, L.; U.P.M. E.T..S.I. Industriales, Madrid, 1985.*

Assessment:

The assessment is based on two partial exams, and also the June and September final exams.

Personal Tutorials:

During working hours.

Additional Information:

The processes of calculation and notation used are coherent with those employed in the structures subjects to follow.

Syllabus:

1. BASIC CONCEPTS

Engineering of structures. Objectives of the analysis of structures. Types of Analysis of structures. Isostatic and hyperstatic structures.

2. REACTIONS AND INTERIOR FORCES IN ISOSTATIC STRUCTURES

Reactions in isostatic structures formed by girders. Reactions in frames and isostatic arches. Concept of interior forces in a section. Equations of balance of the basic slice. Securing of forces in isostatic structures of articulated joints. Cable structures. Funicular curves.

3. RELATIONS OF TENSIONAL EQUILIBRIUM IN ELASTIC SOLIDS

Tensor of tensions on a point. Equations of equilibrium: internal and in the boundary. Tensions and principle directions. Maximum tangential tensions. Mohr's circle.

4. RELATIONS BETWEEN MOVEMENTS AND STRAIN

Strain tensor. Principal directions of strain. Directions of maximum tangential strain. Conditions of compatibility.

5. RELATIONS TENSIONS/STRAINS. CONSTITUTIVES EQUATIONS

Models of behavior of materials. Constitutive equations of lineal elasticity. Module of transversal elasticity. Superimposition of tensional states. Strains and tensions for thermal variations. Energy of strain in lineal elasticity.

6. BAR ELEMENTS SUBJECTED TO AXLE FORCE AND FLECTION

Tensions and deformations in sections with axial and bending forces. Tensions and strain s in sections with axial and bending forces. Sections composed of various materials. Strain energy. Central nucleus.

7. BAR ELEMENTS SUBJECTED TO UNIFORM TENSION

Tensions and strains in uniform torsion. Circular sections. Solid sections. Open sections of thin walls with arbitrary shape. Closed sections of one or several areas. Sections without buckling. Energy of buckling.

8. BAR ELEMENTS SUBJECTED TO SHARP FORCES

Tangent tensions produced by shear force. Open thin sections. Closed sections of one or several enclosures. Energy of buckling.

9. CALCULATION OF MOVEMENTS IN BAR STRUCTURES

Integration of the differential equation associated with buckling. Integration of buckling. Bresse Formulas. Mohr's Theorems.

10. HYPERSTATIC GIRDERS

Girders of one or two spans. Forces created by movements in the supports. Interior articulations. Elastic supports. Symmetry and antimetry.

11. FLAT STRUCTURES OF RIGID JOINTS. ELEMENTAL PORTICOS

Hypothesis of buckling. Translationality and intranslationality. Symetry and antimetry. Equations of rigidity of the straight bar to bending. Resolution of plane porticos. Inclined bars. Semirigid links.

12. PLANE ORTOGONAL GRILLAGE

Equations of rigidity to bending and torsion of the bar. Fixed, articulated and semirigid links. Symetry and antimetry. Cantilever beams.

13. STRUCTURES FORMED BY CURVED BARS. ELEMENTAL ARCHES

Concept of antifunicular line and structure. Arches of parabolic and circular direction. Trussed and bi-fixed arches. Interior articulations. Arches with assymetry. Symetry and antimetry.

14. LINES OF INFLUENCE

Concept of line of influence. Principle of Virtual Works. Theorem of reciprocity. Lines of influences of reactions, forces and movements.

Metric and Descriptive Geometry

DEPARTMENT:	**Industrial Engineering**
LECTURER IN CHARGE:	**Jesús-María Urrutiay de Lambarri**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Compulsory Annual**
CREDITS:	**2 hours per week. 6 CC. 4.5 EC.**

Aims:

To know, to understand and to apply the methods which Descriptive and Metric Geometries give in order to solve geometrical problems and the intersection of surfaces by graphic methods.

Teaching Organization:

This is an annual subject, 6 CC developed in two lessons of one hour per week in a theoretical and also theoretical-practical way.

Bibliography:

- *"Geometría Métrica", Pedro Puig Adám;Ed. Nuevas Gráficas .2 Vol.*
- *"Apuntes de Geometría Métrica", Luciano Olabarrieta.*
- *"Problemas de Geometría Métrica ", Luciano Olabarrieta.*
- *"Geometría Descriptiva Superior y Aplicada", F. Izquierdo Asensi;t Editorial Dossat.*
- *"Geometría Descriptiva Tomos I y III.", Taibo; Editorial Tebar Floresl.*
- *"Geometría Constructiva y sus aplicaciones",Editorial Labor..*

Assessment:

To pass 'by course': An average of two partial exams and one monographic coursework, together with the average of the course practices (the partial exams and the coursework only will be taken into account if their marks are equal or above 3.5 out of 10. In any other case, the students must make up for this doing the corresponding part in the June final examination). September examination: The whole contents.

Personal Tutorials:

Fixed timetable: Tuesday and Friday from 12:30 to 14:00. Out of fixed timetable: to be arranged between the student and the lecturer.

Additional Information:

Syllabus:

1. METRIC GEOMETRY

Axiomatic systems. Axioms of existence, linking, array and division. Points, straight and notable angles in the triangle. Proportionality of segments. Thales' Theorem. Homothetics. Similarity. Constructions. Relations in the circumference. Radical axis. Harmonics Quarters. Circumference beams. Polar. Pole of a straight line.

2. PROJECTIVE GEOMETRY

Transversals in the triangle. Menelao and Ceva's Theorems. Harmonic relation, Principle of Duality. Homology: determination of homologic figures, coefficient, axis, properties. Homography, projectivity, involution: limit points. Pascal and Brianchon's Theorem: application. Pole and polar: determination and construction. Homothetics: homothetic figures, similar figures, center and axis. Radical axis: strength of a point. Inverse figures.

3. REVIEW OF DESCRIPTIVE GEOGRAPHY

Review of interfacial systems, axonometric and bounded systems: alphabet of the point, straight line and planes; distances and angles; straight and plane interactions and between planes; castings and movements.

4. STUDY OF SURFACES

Elements of the theory of surfaces: definition, generation (geometric places, encircling) tangent plane; normal in a point, outlines. Classifications of surfaces. Polyhedrons, basic structures, positions, sections for planes, intersections.

5. REPRESENTATION OF SURFACES

Pyramid: Generation, representation, situation of a point, plane sections, intersection with a straight line, developing and laying out of a geodesic line. Straight and oblique prisms: Idem. Sphere: Generation, representation, apparent outlines, situation of a point, hidden and visible parts, tangent planes, section planes, intersection with a straight line. Cones: Idem. Developments and geodesic lines. Cylinders: Idem.

6. THEOREMS ON INTERSECTION OF QUADRICS

Intersections of prisms and pyramids. Intersections of cones and spheres. Intersections of cylinders and sphere. Intersections of cones and cylinders. Intersections of figures of revolution (method of the spheres). Generalities, general methods of planes fo r the vertices, types of intersection, penetration, tangency and double tangency, method of contraprojection, of tracing, special cases.

7. FIGURES OF REVOLUTION

Torus. Scotland. Ellipsoid. Paraboloid. Hyperboloid of two blades: Methodology of intersection of these surfaces for their condition of quadrics or of revolution surfaces; Generation and representation; situation of a point, tanget plane in a point.

8. DEVELOPABLE AND BUCKLED ADJUSTED SURFACES

General generation, general view of bucked adjusted surfaces, surfaces of director plane, of director cone, helizoid, Chasles' Theorem, accordant surfaces, properties of the adjusted beams, hyperbolic paraboloid. Buckled hyperboloid. Conoids. Helicoid of the director plane: Generation, double generation (director planes), representation, situation of points, tangent planes, asymptotic plane, flat sections, methodology of its intersection with other surfaces.

9. SURFACES OF DIFFICULT REPRESENTATION

Surfaces of difficult representation: forms of planes (concept and distri bution), methods of smoothing or correcting the form (method of highlighting ,oblique sections, of cone or tangent cylinder). Interpolation of sections (methods). Development of the surface (method of diagonals, of straight base, of geodesics) lay-out or ordered charts (disposition and use).

Hydraulics and Hydrology I

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Jerónimo Puertas Agudo**
OTHER LECTURERS:	**Ricardo Juncosa Rivera**
YEAR:	**2nd**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 6.5 EC.**

Aims:

To show the basis of fluid mechanics and the fundamental equations that rule the behavior of fluids in conductions, including technological aspects of the calculation of the flow in pipes and in open channel. At the same time, the basic concepts of qualitative hydrology are introduced.

Teaching Organization:

The teaching activity is based on three hours per week sessions, where theoretical aspects together with the resolution of some previously posed exercises are carried out. The students have to do also some coursework making use of the Hydraulics Laboratory of the School.

Bibliography:

- *"Mecánica de Fluidos", Shames, I., Mc. Graw-Hill, Bogotá, 1995*
- *"Hydraulics in Civel Engineering", Chadwick, A. and Morfett, J., Harper Collins, London,1986*
- *"Mecánica de los fluidos", Streeter, V.L., Mc. Graw-Hill, New York,1958*
- *"Open Channel Flow", Chow,V.T., Mc. Graw-Hill, New York, 1959*

Assessment:

To pass the subject it is necessary to have done correctly the laboratory coursework. The assessment is based on two partial exams besides the final exams of June and September. To pass the course it is necessary to obtain a mark of 5 out of 10 at each partial exam, or at any of the final ones. The passed partials are kept till September.

Personal Tutorials:

Posted at the beginning of each academic course.

Additional Information:

It is considered that the student has assimilated the mathematical and physics contents of the first year.

Syllabus:

1. INTRODUCTION TO THE SUBJECT
2. MECHANIC CHARACTERISTICS OF FLUIDS
3. HYDROSTATICS: BASIC EQUATIONS
4. HYDROSTATICS: CALCULATION OF BALANCES AND THRUSTS
5. MOVEMENT OF FLUIDS IN CONDUITS. BASIC EQUATIONS
6. DIMENSIONAL ANALYSIS
7. INTRODUCTION TO THE IDEA OF BOUNDARY LAYER
8. STUDY OF PERMANENT MOVEMENT IN PIPELINES
9. TURBOMACHINES
10. NON-PERMANENT MOVEMENT IN PIPELINES
11. INTRODUCTION TO THE STUDY OF MOVEMENT IN FREE SHEETS
12. PERMANENT AND UNIFORM MOVEMENT IN CANALS
13. SPECIFIC ENERGY
14. HYDRAULIC JUMP. DISSIPATION OF ENERGY
15. GRADUALLY VARIED OPEN CHANNEL FLOW
16. RAPIDLY VARIED MOVEMENT. TRANSITIONS
17. RAPIDLY VARIED MOVEMENT. OUTLETS AND SPILLWAYS
18. PHYSICAL MODELS
19. INTRODUCTION TO HYDROLOGY
20. PRECIPITATION
21. EVAPORATION, TRANSPIRATION AND INTERCEPTION
22. INFILTRATION AND SOIL HUMIDITY
23. SURFACE RUNOFF. ANALYSIS OF CAPACITY
24. HYDROGRAPH ASSOCIATED TO A PRECIPITATION
25. FLOODS IN RIVERS
26. SUBTERRANEAN HYDROLOGY. BASIC CONCEPTS
27. SUBTERRANEAN HYDROLOGY. EQUATIONS AND METHODS
28. UPTAKE HYDRAULICS

Geology and Introduction to Geotechnical Engineering

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Jordi Delgado Martín, Francisco Padilla Benítez, Jorge Molinero Huguet**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 9 EC.**

Aims:

To introduce the student to key concepts of geology and elemental geotechnics through the methodological and practical analysis of problems of interest for the Civil Engineer.

Teaching Organización:

Lectures (4 hours each week) including theoretical concepts and problems. In addition, a laboratory coursework and a field trip is included as a main part of the course..

Bibliography:

- *"Geografía Física", Strahler, A.N.; Omega, 1977.*
- *"Geología de España", Comba, J.A. (Ed.); IGME, 1983.*
- *"Geotecnia y Cimientos I y II", Jiménez Salas, J.A.; Justo, J.L.; Rueda, Madrid, 1975 and 1981, respectively.*
- *"Fundamentals of soil behaviour", Mitchell, J.K.; John Wiley, Londres, 1993.*
- *"Ciencias de La Tierra", Tarbuck and Lutgens; Prentice Hall, Madrid, 1999.*

Assessment:

In order to pass the course it is mandatory to perform and pass with sufficiency the practicum program. Two non-absolving partial examinations (apart from the ordinary June and September final examinations) will be held. It is necessary to reach a minimum mark in order to avoid the final examinations. In the mark will be considered the eventual reports and coursework requested by the lecturers.

Personal Tutorials:

To be convened, beforehand, with each lecturer.

Additional Information:

The course is divided into two clearly differentiated conceptual parts: Geology and Introductory Geotechnics. Both parts are integrated in order to give the student a comprehensive view of the interactions between geology and engineering.

Syllabus:

1. **INTRODUCTION TO GEOLOGY.**
   The role of geology in civil engineering. Key concepts in Geology: I) Cycles: the rock cycle, the hydrological cycle, geochemical cycles; II) Time: relative and absolute dating; III): Scale: atomic scale processes, planetary-scale processes. The Principles of geology. Time in geology. Geochronology. Origin, structure and evolution of Earth. Earthquakes. Geodesy. Thermal Flux. Isostasy. Subsidence. Paleomagnetism. Plate Tectonics.

2. **MINERALOGY.**
   Chemical bonding. Electronegativity. The mineral concept. Crystal chemistry. Physical properties. Study methods. Systematics. Minerals of interest for the civil engineer.

3. **PETROLOGY I. IGNEOUS ROCKS.**
   Introduction to petrology. The rock concept. Classification of rocks. Composition, texture and structure of igneous rocks. Magma. Differentiation and fractional crystallization. Plutonism. Volcanism. Igneous rocks classifications. Engineering properties.

4. **PETROLOGY II. SEDIMENTARY ROCKS.**
   Sediments and sedimentary rocks. Sedimentation cycles. Sedimentary rock classification. Stratum, sedimentary formation, sedimentary sequence, sedimentation basin. Sedimentary structures. Diagenetic processes. Detrital, carbonated and evaporitic rocks. Engineering properties.

5. **PETROLOGY III. METAMORPHIC ROCKS.**
   Types of metamorphism and factors. The metamorphic facies concept. Geothermometry and geobarometry. Products of metamorphism. Metamorphic textures. Foliations and Schistosity. Important ideas for civil engineers.

6. **METEORIZATION AND SOIL FORMATION**
   Mechanical, biological and chemical meteorization. Factors controlling meteorization. Edafic processes. Soil profile.

7. **GEOMORFOLOGY**
   Erosive processes. Transport mechanisms. Mass wasting and hillslope evolution. Glaciarism. Surface water erosion. Rivers and other water flow systems. Longitudinal profile of rivers. Terraces. Eustatic and climatic changes. Marine and litoral action. Wind erosion.

8. **TECTONICS**
   Strain scale. Fragile Strain. Joints. Rock massif and rock matrix. Elements, structures and types of faults. Faults and stress fields. Ductile strain. Folds. Fold classification. Diapirs. Thrusts. Microtectonics. Schistosity.

9. **GEOLOGY OF THE IBERIAN PENINSULA**
   Geodynamic evolution. Hercynian cycle. Morphostructural units. Alpine ranges. Neogene basins. Geology of Galice.

10. **SOIL STRUCTURE**
    Soil macro and microstructure. Clay mineralogy and water structure.

11. **SOIL CLASSIFICATION AND DESCRIPTION**
    Variables characterizing phase distribution. Tests to determine phase distribution. Granulometric curve: Screening and sedimentation tests. Atterberg limits. Tests to classify soils and rocks.

12. **THE EFFECTIVE STRESS PRINCIPLE**

13. **WATER FLOW IN SATURATED SOILS**
    Introduction. Darcy's Law. Permeability determination in the laboratory and 'in situ'. Laplace's equation. Boundary problems. Resolving of the flow problem. Graphical method: Drainage networks. Multilayer media. Siphoning. Filters. Drains. Free surface.

Differential Geometry

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Ramón Martul Álvarez de Neyra**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Four-Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4.5 EC.**

Aims:

To learn the tools which Classical Differential Geometry and Field Theory place at the disposal of the engineer.

Teaching Organization:

Once the theory of each theme has been developed, the students set out-by groups-the correspondent practical exercises.

Bibliography:

- *"Lectures on Classical Differential Geometry", Struik, D.J., Dover Publications, Inc., New York, 1988 (reimpression)*
- *"Geometría Diferencial", López de la Rica, A. y de la Villa, A., I.C.A.I., Madrid, 1986*
- *"Geometría diferencial de curvas y superficies", do Carmo, M.P.,Alianza Universidad Textos, Madrid,1990*
- *"Vectors and Tensors in Engineering and Physics", Danielson, D.A., Addison-Wesley, New York, 1992*
- *"Vector Analysis for Engineers and Scientists", Lewis, P.E. and Ward, J.P., Addison-Wesley, New York, 1992*
- *"Advanced Engineering Mathematics", Kreyszig, E., John Wiley & Sons, New York, 1988.*

Assessment:

To demonstrate efficiency in the subject, it is required to pass any of the final exams, which take place in three annual sessions: February June and September.

Personal Tutorials:

During working hours.

Additional Information:

To study the course it is advisable to be able to manage fluently the Infinitesimal Calculus of one or several variables, the Lineal Algebra and the Analytical Geometry.

Syllabus:

1. INTRODUCTION TO CURVES

Analytic representation. Requisites of continuity and differentiation. Taylor's Process. Regular and singular points. Change of parametrization. Orientated curves. Vector velocity. Unitary vector target. Examples.

2. LOCAL THEORY OF BUCKLED CURVES

Oscillating plane. Normal principle. Vector curvature. Curvature. Convention of signs. Angle of contingency. Radius of curvature. Oscillating circle. Binormal. Torsion. Curvature and torsion in terms of an arbitrary parameter. Curved planes. Frenet's formulas. Frenet's Trihedron. Projections of the curve on the oscillating rectifying and normal planes.

3. INTRODUCTION TO SURFACES

Analytic representation. Requisites of continuity and differentiation. Taylor's Process. Regular and singular points. Parametric curves. Curvilinear coordinates. Change of parametrization.

4. METRICS ON A SURFACE

Curves on a surface. First fundamental form. Length of an arc. Angle between different tangents. Tangent plane. Normals. Element of area.

5. EXTRINSIC GEOMETRY OF SURFACES

Normal vector curvature. Geodesic vector curvature. Second fundamental form. Asymptotic and non-asymptotic directions. Asymptotic lines. Meusnier's Theorem. Elliptic, parabolic and hyperbolic points. Curvatures and main directions. Lines of curvature. Euler's Theorem. Total and average curvature.

6. INTRODUCTION TO THE THEORY OF FIELDS

Scalar, vectorial and tensorial fields. Directional derivatives. Operator ∇. Gradient. Laplacian. Divergence. Rotational. Expressions in the different systems of coordinates. Examples and applications.

7. INTEGRAL THEOREMS

Multiple integrals, line and surface integrals. Green's Theorem. Integrals of surface. Ostrogradski-Gauss's Theorem. Elements of power theory. Stokes' Theorem. Conservative and dissipative fields. Applications.

General and Applied to Public Works Economics

DEPARTMENT:	**Applied Economics I**
LECTURER IN CHARGE:	**Alejandro M. Vasallo Rapela**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4.5 EC.**

Aims:

To analyze the working mechanisms of an economy from a global point of view. To make an introduction to the generality of economic problems in the companies and the different existing approaches for their resolution. To study the Economy of Construction as an economic activity within the General Economy.

Teaching Organization:

Throughout the course lectures on theory are given and practical cases are commented on. The students, distributed in teams, must do a coursework.

Bibliography:

- *"Economía, Teoría y Política",Mochon Morcillo F. (1994). Ed. McGraw- Hill. Madrid.*
- *"Introducción a la Economía Positiva", Lipsey R.G (1993). Ed. Vicens- Vives. Barcelona.*
- *"Economía", Wonnacott R. J., Wonnacott P. (1992). Ed. McGraw- Hill. Madrid.*
- *"Curso de Economía", González Paz, J. (1998). Ed. Debate. Volumes I, II, and III. Madrid.*
- *"Economía ", Samuelson P. y Nordhaus. W.D. (1993). Ed. McGraw- Hill. Madrid.*
- *" Economía", Fischer S., Dornbusch R., y Schmalense. (1992). Ed. McGraw- Hill. Madrid.*

Assessment:

Final exams will be held in February and September, and the coursework carried out in teams throughout the academic year will be taken into account.

Personal Tutorials:

In working hours.

Additional Information:

Syllabus:

1. **BASIC CONCEPTS. SUPPLY AND DEMAND**
   The concept and method in Economics. Shortage and choice. The economic problem. Economic activity and the economic agents. Supply and Demand. The mechanism of the market. The economic function of the State.

2. **THE COMPANY AND PRODUCTION**
   The company and its financing. The theory of production and costs.

3. **THEORY OF DISTRIBUTION**
   Supply and demand of the production factors. Fixing prices of production factors in competitive markets. Internet and performance of capital.

4. **THE MACROECONOMIC ANALYSIS**
   National Accounting. Macroeconomy. Principal problems: Unemployment and inflation. The Public Sector economy. Aspects of the International Economy.

5. **FINANCING OF ECONOMIC ACTIVITY**
   Money and the financial system.

6. **SECTORIAL AND MACROECOMOMIC POLICIES**
   Fiscal and Budget Policy. Monetary Policy. Income Policy: Control of prices and salaries. Economic Development Policy. Health Policy: Housing and Urbanism.

7. **THE CONSTRUCTION SECTOR**
   Economic influence. Structure and localization of demand. Structure of the range of offers. Financing. Functional Organization.

8. **PUBLIC WORKS DEMAND**
   Investment in public works. Relation with the National Income . General effects of the infrastructures. Public works and regional development.

9. **PROJECT OF INVESTMENT IN PUBLIC WORKS**
   Efficiency of public investments. The assessment of projects: the general framework, Economic analysis and financial analysis.

10. **ADMINISTRATIVE AND INSTITUTIONAL ASPECTS**
    Special administrations in public works.

Mechanics

DEPARTMENT:	**Energy and Maritime Propulsion**
LECTURER IN CHARGE:	**Mar Toledano Prados**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4.5 EC**

Aims:

Training students in engineering mechanics so as to solve some engineering applications related to mechanics in Civil Engineering.

Teaching Organization:

As a general rule, during the course, the lecturer will dedicate two hours per week to theory and two hours per week to solving problems.

Bibliography:

- *"Mecánica vectorial para ingenieros (2 Vol.)", Beer,F.P. y Johnston,E.R., Mc Graw-Hill, Méjico, 1992.*
- *"Mecánica clásica", Goldstein, H., Reverté, Barcelona, 1990.*
- *"Física teórica, Vol. 1: Mecánica", Landau, L.D. y Lifshitz, E.M., Reverté, Barcelona, 1988*
- *"Dinámica clásica de las partículas y sistemas", Marion, J.B., Reverté, Barcelona, 1991.*
- *"Estática", Meriam, J.L., Reverté, Barcelona, 1991.*
- *"Dinámica", Meriam, J.L., Reverté, Barcelona, 1991.*

Assessment:

The evaluation is carried out through the final exams in June and September.

Personal Tutorials:

The teacher will give the information about the hours for personal tutorials at the beginning of the course.

Additional Information:

Syllabus:

1. **DYNAMICS OF RIGID BODIES IN PLANAR MOTION**
   Newton's Laws. Energetic concepts. Conservation law. Linear and angular momentum. Momentum principles. Impact between bodies. Vibrations.

2. **PARTICLE KINEMATICS**
   Velocity and acceleration. Cartesian and intrinsic coordinates. Orthogonal curvilinear coordinates: polar, cylindrical and spherical. Interpretation.

3. **KINEMATICS OF RIGID BODIES**
   Field of velocities. Tangent helicoidal axis. Instantaneous centre of rotation. Base line and rolling circle. Field of accelerations. Steady and inflexion circumference. Acceleration pole.

4. **PARTICLE DINAMICS**
   Newton's laws applied to particular physical problems. Resultant force as a function of velocity and location. Polar coordinates.

5. **DINAMICS OF PARTICLE SYSTEMS**
   Newton's laws. Energy principles. Linear and angular momentum. Observations from a moving reference system. Kinetic energy. Angular momentum principle.

6. **MASS GEOMETRY**
   Inertia matrix. Definition. Inertia properties. Invariants. Components. Steiner principle and applications. Inertia ellipsoid.

7. **DINAMICS OF RIGID BODIES (3D)**
   Tensional study of the motion of rigid bodies in three dimensions. Linear and angular momentum. Energy principles. Newton's laws. Euler equations. Kinetic energy equations.

8. **ANALYTICAL DINAMICS**
   D'Alembert method. Generalized forces. Lagrange's equations. Conservation theorems. Hamilton's principle.

9. **STATICS**
   Statics of a particle. Constraints or links between a surface and a curve. Stable equilibrium. Statics of rigid bodies and systems of rigid bodies. States of equilibrium.

10. **ANALYTICAL STATICS**
    Variational formulation applied to statics of systems. Method of virtual works and virtual displacements. Application to structures. Internal forces considerations.

11. **VIBRATIONS**
    Free vibrations with one and two degrees of freedom. Natural frequencies and mode shapes. Oscillatory systems with *n* degrees of freedom. Wave equation and general solution in one dimension: method of separation of variables.

Transports and Land Use

DEPARTMENT:	**Architectural Projects and Urbanism**
LECTURER IN CHARGE:	**Carlos Nárdiz Ortiz**
OTHER LECTURERS:	**Juan Creus Andrade**
YEAR:	**2nd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4.5 EC.**

Aims:

To introduce the student to the territorial processes which cause the transport infrastructures which an engineer plans and builds. To bring the students closer to a view of land as a historic construction, based on cartography, showing the role of transport in its formation and transformation.

Teaching Organization:

The course has a theoretical component derived from the program explanation and a practical component derived from the coursework the students do in a continuous and individualized way, in order to study a specific territorial strip, the influence which the transport infrastructures had had on its process of formation and transformation. It is considered in this sense that, due to its compulsory character, this course constitutes the base for other subjects in later courses, in which the relations between the infrastructures and the land can be studied in depth.

Bibliography:

- *"El Territorio y los Caminos en Galicia. Planos Históricos de la Red Viaria,Carlos Nárdiz Ortiz. Ed. Xunta de Galicia. Colegio de Ingenieros de Caminos, C.y P.,1992.*
- *"Resumen Histórico del Urbanismo en España", Garcia Bellido y otros. Instituto de Estudios de la Administración Local. Madrid,1968.*
- *"Territorio y Ciudad en la España de la Ilustración", Carlos Sambricio, Ed. MOPT. Madrid, 1991.*
- *"Diseño de la Ciudad-5. El arte y la Ciudad Contemporánea", Leonardo Benevolo. Ed. Gustavo Gili. Barcelona,1981.*
- *"La Coruña. Metrópolis Regional", Andrés Precedo. Fundación Caixa Galicia, 1990.*
- *"Plan Director de Infraestructuras", Publicaciones del MOPTMA, 1994.*

Assessment:

The assessment is based on an practical exercise developed in phases in an individualized way, and a final exam.

Personal Tutorials:

During working hours. Tutorials are established furthermore for practical exercises.

Additional Information: Information derived from the historical and current cartography in different scales.

Program:

1. **TRANSPORT AND TERRITORY. CONCEPT**
2. **THE PROCESS OF URBANIZATION OF LAND**
3. **CARTOGRAPHY AS AN INSTRUMENT OF ANALYSIS OF THE TERRITORY**
4. **THE ELEMENTS OF ANALYSIS OF A LAND STRUCTURE**
5. **TRANSPORT AND LAND IN THE PAST**
6. **URBANIZATION OF MEDIEVAL LAND**
7. **URBAN STRUCTURE OF THE MEDIEVAL CITY**
8. **THE NEW FORMS OF INTERVENTION IN THE CITY FROM THE 16TH CENTURY**
9. **TRANSPORT AND LAND IN THE 18TH CENTURY**
10. **THE CITY OF THE ILLUSTRATION, BAROQUE AND MILITARY URBANISM**
11. **TRANSPORT AND LAND IN THE 19TH CENTURY**
12. **THE CITY OF THE 19TH CENTURY. THE SUBURB AND INTERIOR REFORM**
13. **TRANSPORT IN THE 20TH CENTURY**
14. **FORMS OF URBAN GROWTH IN THE 20TH CENTURY**
15. **TERRITORIAL SYSTEMS AND TRANSPORT NETWORKS**
16. **INFRASTRUCTURES OF TRANSPORT AND THE ENVIRONMENT**

3.1.7.3. THIRD YEAR

Numerical Calculus

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Ignasi Colominas Ezponda**
OTHER LECTURERS:	**Fermín Navarrina Martínez and Gonzalo Mosqueira Martínez**
YEAR:	**3rd**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 8.5 EC.**

Aims:

To know, to understand and to apply the main numerical methods for solving the most common problems in Civil Engineering.

Teaching Organization:

The theoretical and practical lectures extend for four hours per week, developing the fundamental theory and solving the exercises and practical problems previously set. In the Centre of Calculus of the School, the students must solve a set of application problems by devising several FORTRAN codes as a part of the work of the course.

Bibliography:

- *"Cálculo Numérico. Métodos. Aplicaciones", Carnahan, B., Luther, H.A. y Wilkes, J.O., Editorial Rueda, Madrid, 1979.*
- *"A First Course in Numerical Analysis", Ralston, A. y Rabinowitz, P., Mc Graw-Hill, New York, 1978.*
- *"Introduction to Numerical Analysis", Hildebrand, F.B., Mc Graw-Hill, New York, 1974.*
- *"Introduction to Numerical Analysis", Stoer, J. y Burlisch, R., Springer-Verlag, New York, 1980.*
- *"Analysis of Numerical Methods", Isaacson, E. y Keller, H.B., John Wiley \& Sons, New York, 1966.*
- *"Numerical Recipes. The Art of Scientific Computing", Press, W.H., Flannery B.P., Teukolsky, S.A. y Vetterling, W.T., Cambridge University Press, Cambridge, 1986.*

Assessment:

In order to pass the course, it is required to submit the programme coursework. Two assessment examinations, in February and June, and two final exams, in June and September, are held. In order to pass the course, it is required to obtain a minimum mark in each partial exam. The mark of the programme coursework and the exercises proposed during the course are taken into account.

Personal Tutorials:

During working hours. In the period of examinations a specific schedule is posted.

Additional Information:

Solid knowledge in FORTRAN language and VMS operative system at a user level is required. It is recommended to take this course simultaneously with Calculus III.

Syllabus:

1. GENERAL CONCEPTS
Historical development of the Numerical Calculus. Main notions. Numerical Methods in Civil Engineering.

2. NUMBER AND ALGORITHM
Concept of number and numeration basis. Data storage in computers: types of variable; accuracy and round-off. Direct algorithms: computing time. Iterative algorithms: convergence order; truncation.

3. ERRORS
Round-off error and truncation error. Propagation and instability. Control of error.

4. ITERATIVE SOLUTION OF NON-LINEAR EQUATIONS
Functional iteration methods: convergence conditions. Successive approximation methods. Newton's methods and derived methods. Aitken's accelerating procedure. Roots of polynomials: Graeffe's method and Bernoulli's method; Rutishauser QD 's algorithm.

5. BASIS OF MATRIX CALCULUS. COMPUTATION OF EIGENVALUES
Storing schemes: full, symmetric, banded, skyline and sparse matrices. Computation of Eigenvalues: standard and generalised problems; reduction and translation; Rayleigh quotient; Rayleigh-Ritz analysis. Vectorial iteration methods: Direct and inverse Mises's methods. Matrix transformation methods: Jacobi and Householder QR.

6. LINEAR SYSTEMS OF EQUATIONS
Immediate systems. Direct methods: Gauss elimination and Gauss-Jordan elimination; LU factorization and LDU Crout and Cholesky factorization; Iterative methods: general statement and convergence conditions; Jacobi and Gauss-Seidel methods; overrelaxation and preconditioning. Semi-iterative methods: conjugate gradient method. Inversion of matrices and computation of determinants. Non-linear systems: succesive approximation methods; Newton-Raphson methods and others derived from Newton-Raphson methods.

7. APPROXIMATION AND INTERPOLATION
Interpolation polynomial: fundamental theorem; Newton's and Lagrange's formulae; optimum sampling and Chebychev economization. Least-squares approximation: fundamental thorem; normal equations; orthogonal polynomials; smoothing. Mini-max approximation. Splines. Computer aided representation: Bezier curves and B-splines. Multidimensional interpolation.

8. NUMERICAL INTEGRATION AND DERIVATION
Newton's integration: open and closed Newton-Cotes quadrature formulae. Gaussian integration: Legendre, Laguerre, Hermite, Chebychev, Radau and Lobatto quadratures. Other techniques: combination of simple formulae; composite formulae; Richardson's extrapolation; Romberg's integration; Filon's integration. Convergence. Treatment of discontinuities and singularities. Multiple integrals. Numerical derivation.

9. ORDINARY DIFFERENTIAL EQUATIONS
Initial and boundary value problems. Euler's method. Consistency, convergence and stability. One-step methods: Taylor's series; Runge-Kutta methods. Multi-step methods: Adams-Bashforth, Moulton and predictor-corrector methods. Richardson extrapolation: step control; Burlisch-Stoer methods. Stiff systems. Shooting method.

10. PARTIAL DIFFERENTIAL EQUATIONS
The Finite Diference method. Consistency, convergence and stability. Parabolic equations: explicit, implicit and Crank-Nicolson's methods; Von Neumann stability analysis. Elliptic equations. Hyperbolic equations. Integral methods: weighted residual methods; trial and test functions; Ritz's method and Finite Element method; Galerkin's method; implementation. Eigenvalue problems. Non-linear problems.

Statistics

DEPARTMENT:	**Mathematical Methods and of Representation**
LECTURER IN CHARGE:	**Manuel Casteleiro Maldonado**
OTHER LECTURERS:	**Javier Gómez Calviño and Fermín Navarrina Martinez**
YEAR:	**3rd**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 6,5 EC.**

Aims:

The subject tries, through the comprehension of the randomness of most of the physical, social and economic phenomena, to show the student the right way to take decisions in the presence of uncertainty.

Teaching Organization:

The teaching activity is three hours per week. No differences will be made between the theoretical and practical sessions. Some exercises will be proposed periodically and later solved during the lecturing hours.

Bibliography:

- *"Probability, Statistics and Decisión for Civivil Engineers", Benjamin, J.R.C.and C. Cornell, McGraw-Hill, New York, 1970.*
- *"Probability and Statistics", Canavos, G.C., McGraw-Hill, México, 1987*
- *"Probability and Statistics", Meyer, P.L., Addison-Wesley Iberoamericana, México, 1992*
- *"Probability, Random Variables and Stochastic Processes", Papoulis, A., McGraw-Hill Kagakusha,Tokyo, 1965*
- *"Statistics. Models and Methods", 2Vol. Peña, D. Alianza Universal, Madrid, 1986*
- *"Introduction to the Probability Theory and Statistics Inference", Durand, A.I. and S.L. Ipiña Ed. Rueda, Madrid, 1994*
- *"Engineering Statistics", Hogg, R.V. and J. Ledolter, Mc Millan, New York, 1987*

Assessment:

The assessment is based on two partial exams. Each partial exam includes all the contents given from the beginning of the course until the time of the exam. During the exam it is allowed to consult any material needed: books, notes, etc. To pass the course it is required to get an average mark in each partial exam, the submitted course work is also taken into account.

Personal Tutorials:

During working hours.

Additional Information:

Some elementary knowledge in Algebra and Calculus is required.

Program:

1. THEORY OF PROBABILITY

Concept of uncertainty. Elements of algebra of sets. Probability: classic definitions and frequential, axiomatic definition. Joint probability, conditional probability. Theorem of total probability: Bayes' theorem. Random variables: discreet, continuous and mixed variables. Discreet random variables: function of probability and function of accumulated distribution. Continuous random variables: function of density and function of accumulated probability. Discrete random variables: functions of marginal density. Independent variables. Changes of variable. Distributions transformed into more than two variables. Integrals of convolution. Momentum of higher order. Properties of mathematical expectation and variance. Momentum of random variables: conditional momentum, covariance, coefficient of correlation. Momentum of the sum and product of random variables. Generating function of momentums. Characteristic function. Inequality of Chebyshev: law of the great numbers. Other inequalities. Experiments of Bernouilli: distribution of Bernouilli, Binominal distribution, Geometric distribution, Pascal's distribution. Hypergeometric Distribution. Poisson's arrivals: Poisson's distribution, Exponential distribution, Gamma distribution. Theorem of central limit: Normal distribution. Analysis of Normal distribution: working of tables. Approximation of other distributions by the Normal. Logarithmic-Normal Distribution: working of tables. Asymptotic distributions of extremes: Gumbel and Weibull distributions, other distributions of extremes. Other distributions: uniform, beta, c^2, c, Student *t*, Student *f*. Modified distributions: truncated, transformed, etc. Distributions in several variables: multinominal distributions and multinormal. Elemental simulation of distributions: Monte Carlo methods.

2. STATISTIC INFERENCE

Historic development. Concept of inference. Specific estimation: method of momentums, means and variance. Distribution of the means: momentums. Distribution of the variance: momentums, quadratic average error. Function of verisimilitude: method of maximum verisimilitude. Biased and unbiased estimators: efficiency, consistency, sufficiency. Confidence intervals on the mean. Confidence Intervals on the variance. Confidence Intervals in the parameters of distributions. Contrast of hypothesis: region of acceptance, critical region. Errors (Type I, Type II): characteristic curve. Types of hypothesis (simple, composite). Symmetrical and non-symmetrical tests. Normal distribution: contrasts of the means and the variance. Contrasts of parameters of distributions. Contrasts based on reason of verisimilitude. Neyman-Pearson Theorem. Analysis of two groups of facts: analysis of correlation. Non-parametric Statistics: testing models, graphic analysis, scales. Contrast c^2: estimated parameters. Contrast of Kolmogorov-Smirnov: graphic execution. Other non-parametric tests: tests on more than one sample. Lineal static models: E [Y]= á+âX; E [Y|X=x]= á+âX; Extension to various variables. Analysis of the variance. Lineal regression. Hypothesis. Intervals of trust on a coefficient. Contrasts on the parameters of regression: analysis of the slope: analysis of the independent term.

Structures II

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**José Angel Jurado Albarracín**
OTHER LECTURERS:	
YEAR:	**3rd**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 8.5 EC.**

Aims:

To complete the formation about traditional methods of calculation in bar structures. Analysis of bar structures in second order theory. Introduction to the bending of slabs and to the study of spherical and revolution shells. Matrix methods for calculation of bar structures.

Teaching Organization:

For 4 hours a week theoretical lectures and exercises are carried out. The students resolve structural models in the Laboratory of Calculation of Structures by means of computer programs.

Bibliography:

- *"Análisis lineal y no lineal de estructuras de barras", S. Hernández, Units 1, 2, 3, 4 and 9..*
- *"Mechanics of Elastic Structures", Oden, J.T., McGraw- Hill, Units 1 to 3.*
- *"Theory of Elastic Stability", Timoshenko y Gere, McGraw- Hill, Units 4 to 9.*
- *"Steel Structures", William MacGuire, Prentice- Hall. Units 4 to 9..*
- *"Teoría de placas y láminas", Timoshenko, Voinowsky, Krieger, Urmo. Units 6 to 9*
- *"Background to Buckling", H..G. Allen, P. S. Bulbon. Unit 8.*
- *"Backing of Bars, Plates and Shells", Brush, Almroth. Unit 8.*
- *" Cálculo matricial de estructuras", Saez- Benito Espada, J.M., F.E.I.N. Units 10 to 14*
- *"Métodos matriciales para cálculo de estructuras", Livesley, R.K., Blume. Units 10 to 14*
- *"Ejemplos resueltos de cálculo matricial de estructuras con el programa SAP90", J.A. Jurado; S. Hernández, Tórculo, 1997, Unit 9.*

Assessment:

There will be two partial exams, and the final exams of June and September.

Personal Tutorials:

During working hours.

Additional Information:

It is assumed that the students know the operative system MS-DOS at a user level.

Syllabus:

1. **PRINCIPLES OF VIRTUAL WORKS**
   Concept of virtual work. Principle of virtual movements. Principle of virtual forces. Applications: Calculation of movements in bar structures. Calculation of hyperstatic structures.

2. **ENERGY THEOREMS**
   Total potential energy of a structure. Minimum condition of the total potentia energy. Minimum value of the strain energy. Castigliano's theorems. Application to hyperstatic structures. Maxwell- Betti's Theorem.

3. **HYPERSTATIC STRUCTURES OF ARTICULATED JOINTS**
   External and internal hyperstaticism. Calculation of hyperstatic reactions. Calculation of structures with internal hyperstaticism. Effects of thermal variations or defects in the length of bars.

4. **ELASTIC INSTABILITY OF BAR STRUCTURES**
   Euler's model of buckling. Isolated bars with different conditions of linking. Concept of length and buckling. Buckling in great strains. Buckling of continuous beams. Buckling of non- traslational porticos. Buckling of traslational porticos. Modes of bucking.

5. **BENDING OF ISOTROPIC SLABS IN ELASTIC LINEAR RANGE**
   Lineal theory of thin isotrope slabs. Definitions and hypothesis. General equations of the problem in cartesian coordinates: Actions and interior forces. Equations of equilibrium, constitutive equations. Equations of compatibility. Kirchhoff and Navier's Hypothesis. Differential equation of the slab. Rectangular slabs. Boundary Conditions. Kirchhoff reactions. Navier's Solution. Levy's Solution. The isotrope slabs in polar coordinates. Formulation of bending. Circular slabs. Boundary conditions. Loads with symmetry of revolution.

6. **BUCKLING OF THIN SLABS**
   Definition of the model. Equations of equilibrium of isotrope slabs under compression in non-linear theory. Equations of linear stability. Criteria of minimal potential energy. Slabs with simply supported edges.

7. **THEORY OF SHELLS IN ELASTIC AND LINEAR RANGE**
   Shells without bending with axial symmetry. Particularization to spheres and cones. Application to pressure tanks. General theory of cylindrical shells in bending.

8. **INTRODUCTION TO BUCKLING IN SHELLS**
   Strain energy in shells. Cylindrical shells in axial compression. Modes of buckling in cylindrical shells.

9. **MATRIX ANALYSIS OF STRUCTURES. METHOD OF EQUILIBRIUM**
   Introduction. Notations for loads and movements. Matrixes of rigidity and flexibility. Conditions of equilibrium and compatibility. Principle of virtual works. Rigid matrix of a straight bar. Coordinate axis of bars and general axis. Matrixes of transport. Equations of equilibrium of joint. Assembly of the matrix of rigidity of the structure. Properties of the matrix of rigidity. Conditions of concordant and non- concordant links. Other types of conditions. Matrix of rigidity in theory of 2^{nd} order: Method of the stability functions. Method of the matrix of geometric rigidity.

10. **DESCRIPTION OF A PROGRAM OF MATRIX CALCULATION OF STRUCTURES**
    Diagram of general flow. System of coordinated axis. Coordinates of the joints. Boundary conditions. Set of geometric and elastic properties of the bars. Set of loads. Definition of bars: connectivity, type of bar, liberation of degrees of freedom, local axis, acting loads, nodal loads. Combination of loads.

Geotechnical Engineering II

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Luis Medina Rodríguez**
OTHER LECTURERS:	**Manuel Melis Maynar and Jorge Molinero Huguet**
YEAR:	**3rd**
TYPE:	**Compulsory Annual**
CREDITS:	**4 hours per week. 12 CC. 8.5 EC**

Aims:

The main aim of this subject is to supply the students with the necessary knowledge and information about Soil Mechanics, introducing the laws and key rules for geotechnical calculus.

Teaching Organization:

Theoretical and practical lectures. Compulsory laboratory exercises.

Bibliography:

- *"Principles of Geotechnical Engineering", Das, B.M. PWS Publishing Company, 1985*
- *"Mecánica de Suelos", T.W. Lambe y R.V. Wihtman, Limusa, 1991.*
- *"Introduction to geotechnical Engineering", R.D. Holtz y W.D. Kovacs, Prentice Hall, 1981.*
- *"Geotecnia y Cimientos I y II", J.A. Jiménez Salas y otros, Editorial Rueda, Madrid, 1975 y 1981.*
- *"The Mechanics of soils", J.H. Atkinson y P.L. Bransby, Mc Graw-Hill, 1978.*
- *"Elastic solutions for soil and rock mechanics", H.G. Poulos y E.H. Davis, Centre for geotechnical reseach, University of Sidney, 1991.*
- *"Soil Mechanics in Engineering Practice", K. Terzaghi y R.B. Peck, John Wiley, 1967.*

Assessment:

Two partial examinations will be made during the course besides the final examinations in June and September. In order to pass the subject the students should attend the laboratory lectures and submit a report about them.

Personal Tutorials:

Six hours per week. The timetable is posted on the student notice board.

Additional Information:

Students must have learnt all the basic concepts concerning Soil Mechanics from the subject *Geology and Introduction to Geotechnics*.

Syllabus:

1. **INTRODUCTION.**
   Soil mechanics and geotechnical engineering. Geotechnical problems. Safety.

2. **STRESSES IN A SOIL.**
   Two dimensional and three dimensional elasticity. Stresses and strains. Hooke's law. Plane strain and plane stress conditions. Mohr's circle of stress. Principal stresses and principal planes. Mohr's circle of strain. Stresses in non continuum media. In situ stresses. Coefficient of earth pressure at rest. Jaky's equation. Mohr-Coulomb failure criteria. Stress-strain behavior of soils.

3. **COMPRESSIBILITY OF SOIL.**
   Introduction. The oedometer. One-dimensional laboratory consolidation test. Normally consolidated and overconsolidated clays. Effect of disturbance on void ratio -pressure relationship. Terzaghi-Frohlich's consolidation theory. Calculation of settlement from one-dimensional primary consolidation. Coefficient of consolidation: logarithm-of-time method and square -root -of-time method. Calculation of consolidation settlement under foundations. Secondary consolidation.

4. **SHEAR STRENGTH OF SOIL.**
   Mohr-Coulomb failure criteria. Direct shear test: drained and undrained test on sands and clays. Triaxial shear test: equipment, porewater, cell and back pressures, total and effective stresses, Skempton's pore water pressure parameters, deviator stress, consolidated-drained test, consolidated-undrained test, unconsolidated-undrained test. Unconfined compression test. Stress paths. Lambe-Withman and Cambridge representations.

5. **STRESSES IN ELASTIC SOIL.**
   Models of elastic behavior. Elastic, homogeneous and isotropic soils (Boussinesq's hypothesis): stresses caused by different load geometries. Elastic layer over rigid substratum. Multi-layer systems. Rigid loads.

6. **PLASTICITY OF SOIL.**
   Kotter's equations. Sokolovski's solution. Numerical solution. The plastic potential and the normality rule. Load capacity analysis. Failure criteria. Three dimensional representation: Von Mises, Treska and Mohr-Coulomb criteria. Drucker-Prager criterion. Critical State models. Visco-plasticity. Rankine's theory.

7. **LATERAL EARTH PRESSURE.**
   Earth pressure at rest. Rankine's theory of active and passive pressures. Lateral earth pressure distribution against retaining walls. Coulomb's earth pressure theory. Poncelet's method. Culmann's graphic solution. Passive earth pressure against retaining walls with curved failure surface.

8. **SLOPE STABILITY.**
   Factor of safety. Stability of infinite slopes without seepage and with seepage. Finite slopes. Analysis of finite slopes with circular failure surfaces. Mass procedure: Taylor's table. Ordinary method of slides. Bishop's simplified method of slides. Janbu's method. Bishop and Morgenstern's solution for stability of simple slopes with seepage. Spencer's solution for stability of simple slopes with seepage.

9. **SOIL BEARING CAPACITY FOR SHALLOW FOUNDATIONS.**
   Ultimate soil-bearing capacity for shallow foundations. Prandtl's equation. Terzaghi's ultimate bearing capacity equation. Meyerhof and Brinch-Hansen formula. Effect of shape and depth of the foundation. Effect of shallow rigid substratum. Effect of groundwater table. Effect of eccentric loads and inclined loads. General bearing capacity equation.

Continuum Mechanics

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Alejandro Mosquera Martínez**
OTHER LECTURERS:	
YEAR:	**3rd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**5 hours per week. 7.5 CC. 6 EC.**

Aims:

To introduce the student to Continuum Mechanics from both a general and particular point of view in subjects like Structures, Hydraulics and Hydrology and Geotechnical Engineering. Elastic, elastic-plastic, viscoelastic and fluid mechanics models.

Teaching Organization:

Three hours of theoretical lectures and two practical hours are given per week, where both suggested exercises and exam exercises from previous years are solved.

Bibliography:

- *"A First Course in Continuum Mechanics" Y.C. Fung, Prentice Hall. Temas 1, 2, 3, 10, 11.*
- *"Foundation of Solid Mechanics" Y.C. Fung, Prentice Hall. Temas 1, 2, 3, 4, 5, 10, 11.*
- *"Introduction to the mechanics of a continuous medium", L.E. Malvern, Prentice Hall. Temas 1, 2, 3, 4, 5, 10, 11.*
- *"Curso de Elasticidad", Samartín, Bellisco. Temas 1, 2, 4, 5, 6.*
- *"Teoría de la elasticidad" Timoshenko y Goodier, Urmo. Temas 1, 2, 4, 5, 6.*
- *"Nociones de cálculo plástico" C. Benito, Revista de Obras Públicas. Temas 7, 8, 9.*

Assessment:

By means of a final exam, in June and September.

Personal Tutorials:

In working hours

Additional Information:

Syllabus:

1. **STRESS EQUATIONS**
   Stress concept. Stress tensor. Equilibrium equations. Mohr's circles.

2. **KINEMATICS OF A CONTINUOUS MEDIUM**
   Motion field variations. Almansi and Hamel strain tensors. Cauchy's strain tensor. Longitudinal and angular deformations. Compatibility conditions. Deformation Mohr's circles.

3. **CONSTITUTIVE EQUATIONS OF A CONTINUOUS MEDIUM**
   Solid behaviour models: Linear and non linear elastic. Elastic-plastic. Viscoelastic. Termoelastic. Fluid behavior models: Non viscous fluid. Newtonian fluids. Non Newtonian fluids.

4. **LINEAR ELASTICITY CONSTITUTIVE EQUATIONS**
   Deformation modulus. Generalized Hooke's law. Shear modulus of elasticity. Volume strain modulus. Lamé equations. Saint-Venant's hipothesis. Navier's equations.

5. **TWO-DIMENSIONAL LINEAR ELASTICITY**
   Plane strain state. Plane stress state. Mohr's circle in 2-D elasticity. Airy stress function. Representative curves of a tensional state. 2-D elasticity in polar coordinates.

6. **PLASTIC BEHAVIOUR OF A CONTINUOUS MEDIUM**
   Spherical and deviatoric stress tensors. Haig-Westergaard's representation. Plastificaction curves and surfaces. Bridgman's and Lode's tests. Plastification criteria: Rankine-Lame; Beltrami and Haig, Von Mises-Hencky, Mohr.

7. **ELASTIC-PLASTIC BEHAVIOUR OF CROSS SECTIONS (I). AXIAL FORCES AND PURE BENDING**
   Plastic moment concept. Shape factor. Sections with one or more symmetry axis. Residual stresses with different moment signs. Plastic hinge concept.

8. **ELASTIC-PLASTIC BEHAVIOUR OF CROSS SECTIONS (II). SIMPLE AND COMPOUND BENDING**
   Deformation hypothesis. Rectangular section. I Sections.

9. **PLASTIC ANALYSIS OF BEAMS AND PORTICOS**
   Isostatic beams. Hyperstatic simple beams. Continuous beams. Porticos in plastic state: Static method; Kinematic method.

10. **VISCOELASTIC BEHAVIOUR OF A CONTINUOUS MEDIUM**
    Viscoelastic models: Maxwell's models. Voigt's models. Linear standard model. Creep and relaxation functions. Viscoplastic solids.

11. **FLUID MECHANICS**
    Navier-Stokes equations. Superficial stress and boundary conditions in a free surface. Parallel plane flow in an horizontal pipe. Non viscous fluids.

Calculus III

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Ignasi Colominas Ezponda**
OTHER LECTURERS:	**Gonzalo Mosqueira Martínez**
YEAR:	**3rd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

To know and to apply the main results of the classical examples in Mathematical Physics, and to know the main analytical techniques for the resolution of Partial Differential Equations.

Teaching Organization:

The theoretical and practical lectures extent for four hours per week, developing the fundamental theory and solving the exercises and practical problems previously set.

Bibliography:

- *"Elementary Applied Partial Differential Equations", Haberman R.; Prentice Hall, 1987.*
- *"Curso de Ecuaciones Diferenciales en Derivadas Parciales", Weinberger H.F.; Ed. Reverté, 1988.*
- *"Partial Differential Equations of Applied Mathema tics", Zauderer E.; John Wiley & Sons, 1988.*
- *"Problemas de la Física Matemática (vols. 1 y 2)", Budak B.M., Samarski A.D. y Tijonov A.N.; Mc Graw Hill, 1993*
- *"Advanced Engineering Mathematics (7th ed.)", Kreyszig E.; John Wiley & Sons, 1993.*
- *"Primer Curso de Ecuaciones Diferenciales en Derivadas Parciales", Peral Alonso I.; Addison-Wesley/Universidad Autónoma de Madrid, 1995.*
- *"Methods of Mathematical Physics (vol. II)", Courant R. y Hilbert D.; John Wiley & Sons, 1962.*

Assessment:

An partial examination in February and two final exams, in June and September, are held. In order to pass the course at the end of the first semester, it is required to obtain a minimum grade in the partial exam and to submit the exercises set during the course.

Personal Tutorials:

During working hours. In the period of exams a specific schedule is posted.

Additional Information:

A solid knowledge in Linear Algebra, Infinitesimal Calculus and Ordinary Differential Equations is required.

Syllabus:

1. INTRODUCTION

Basic notions and definitions (Concept of mathematical problem; General aspects about the resolutions of a differential equation; Grade and Order of a Partial Differential Equation (PDE); Linear and Non-linear operators; Homogeneous partial differential equations; Principle of Superposition; General methods for solving PDEs). Revision of the main concepts of first and second order ordinary differential equations (ODEs).

2. STATEMENT OF PROBLEMS IN MATHEMATICAL PHYSICS

Introduction (Initial value problems and boundary value problems; Conditions of Hadamard for a well-posed problem). The Diffusion Equation (Derivation of the heat conduction equation in a rod; Initial and boundary conditions; Equilibrium temperature distribution; Derivation of the heat conduction equation in 2D and 3D; Statement of problems in polar, cylindrical and spherical coordinates; Physical phenomena governed by this PDE). The Wave equation (Derivation of the "vibrating string" differential equation; Initial and boundary conditions; Derivation of the wave equation in 2D and 3D; Physical phenomena governed by this PDE). The Laplace's equation (Physical phenomena governed by the Laplace's differential equation; Qualitative properties of the solutions). Classification of second-order PDEs with two-independent variables (Types; Transformation to canonical forms; Equations with constant coefficients).

3. FIRST-ORDER PARTIAL DIFFERENTIAL EQUATIONS

Introduction (Physical phenomena governed by first-order PDEs; Reduction of high-order equations to systems of first-order differential equations). Linear equations (Method of Characteristics; Application to the one-dimensional wave equation; D'Alembert's solution). Quasi-linear and non-linear equations (Solution by using the Method of Characteristics; Shock waves; Application to traffic flow problems).

4. METHOD OF SEPARATION OF VARIABLES

Revision of basic notions (Ortogonality of functions; Fourier's Series). Sturm-Liouville eigenvalue problems for ODEs (General Classification; Eigenvalues and eigenfunctions; Properties of the regular Sturm-Liouville eigenvalue problems; Singular problems; Generalized series of eigenfunctions). Solution of homogeneous second-order linear PDEs (Method of separation of variables; Separated equations; Resolution of the heat conduction equation in a rod and in a ring, the vibrating string equation and the vibrating circular membrane equation, and the Laplace's equation in a rectangle and a circle). Solution of PDEs with at least three independent variables (Multidimensional Fourier series; Statements and illustrations of theorems for multidimensional eigenvalue problems; Solution of homogeneous multidimensional problems; Application of the diffusion equation, the wave equation and the Laplace's equation to mutidimensional problems).

5. NON-HOMOGENEOUS PROBLEMS

Transformation of non-homogeneous problems to homogeneous ones (Application to the heat conduction problem). Method of eigenfunction expansion (Term-by-term differentiation and integration of Fourier's Series; Obtaining of eigenfunctions; Solution of a non-homogeneous problem by using series; Application examples).

6. GREEN'S FUNCTIONS FOR BOUNDARY VALUE PROBLEMS

Introduction (Obtaining the Green's function by using the series solution of the problem). Green's functions for ordinary differential equations (Application to the steady-state heat conduction equation; Physical explanation of the Green's function; Properties; Solution of problems with non-homogeneous boundary conditions). Green's functions for boundary value problems in 2D and 3D: the Poisson's equation (Revision of the theorem of divergence and Green's Identities; Solution of boundary value problems with homogeneous and non-homogeneous boundary conditions; Method of eigenfunction expansion; Obtaining Green's functions for infinite and semi-infinite 2D and 3D problems: Method of images).

7. INTEGRAL TRANSFORMS

Motivation of the use of integral transforms (Aims; Types of integral transforms). Laplace's Transforms (Definition; Properties; Application to the solution of first and second order PDEs). Fourier's Transforms (Fourier's Integral of a function; Types of Fourier's transforms and properties; Application to the solution of academic boundary value problems). Application of the transforms of Laplace and Fourier to civil engineering problems.

Materials Science

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Alejandro Mosquera Martínez and Jorge Molinero Huguet**
OTHER LECTURERS:	
YEAR:	**3rd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**5 hours per week. 7.5 CC. 6 EC**

Aims:

Providing a general view about the most accepted models on fracture mechanics within the context of civil engineering. Providing knowledge about topics related with material physics: anelastic constitutive equations, creep and relaxation, general plastic behavior, corrosion and material aging.

Teaching Organization:

Five hours per week including theoretical and practical sessions.

Bibliography:

- *"The Practical Use of Fracture Mechanics", Broek, D., Kluwer Academic Pub., 1989.*
- *"Advanced Fracture Mechanics", Kanninen, M.F. y Popelar, C.H., Oxford Eng. Sciences Series, 1985.*
- *"Numerical Fracture Mechanics", Aliabadi, M.H. y Rooke, D.P., Kluwer Academic, 1991.*
- *"Código Modelo CEB-FIP 1990".*
- *"Engineering Materials 1", Michael F. Ashby y Davis R.H. Jones., Int.Series Materials Science and Technology, volumen 34, 1991.*
- *"Ciencia de los Materiales", J.C. Anderson, Limusa Noriega Editores, 1998.*
- *"Ciencia e Ingeniería de los Materiales", José Antonio Pero-Sanz Elorz, CIE Inversiones Editoriales, 2000.*
- *"Creep of plain and structural concrete", Neville, Construction Press-Longman.*
- *"Corrosion Engineering", Fontana, M.G., MacGraw-Hill Inc., 1986.*
- *"Corrosión y control de corrosión", Uhlig, H.H., Ed. Urmo, 1979.*
- *"Introduction to the Mechanics of Continuous Medium", Malvern, L.E., Prentice-Hall, 1969.*

Assessment:

Regular examination (June and September).

Personal Tutorials:

Working time.

Additional Information:

Syllabus:

1. **INTRODUCTION**
2. **FAILURE MECHANISMS**
3. **STRESS CONCENTRATIONS. NOTCHES.**
4. **LINEAR ELASTIC FRACTURE MECHANICS**
5. **STRESS INTENSITY FACTOR**
6. **THE ENERGY CRITERION**
7. **ELASTIC-PLASTIC FRACTURE MECHANICS I**
8. **ELASTIC-PLASTIC FRACTURE MECHANICS II**
9. **COHESIVE FRACTURE**
10. **FATIGUE MODELS**
11. **FATIGUE FRACTURE**
12. **PRACTICAL ASPECTS ON FRACTURE MECHANICS**
13. **STEEL RELAXATION**
14. **TIME-DEPENDENT STRAINS IN CONCRETE**
15. **FIELD AND BOUNDARY EQUATIONS**
16. **INTRODUCTION TO MATERIALS PLASTICITY**
17. **GENERAL FORMULATION OF PLASTICITY**
18. **MAIN PLASTIC MODELS**
19. **APPLICATION IN COMPUTER CODES**
20. **CORROSION OF METALS**
21. **CONCRETE AGING**

Hydraulics and Hydrology II

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Ricardo Juncosa Rivera**
OTHER LECTURERS:	**Javier Samper Calvete, Francisco Padilla Benítez**
YEAR:	**3rd**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

The subject gives the students the fundaments and the methods of calculation on Hydraulics not only on the surface but also under the ground.

Teaching Organization:

The teaching activity is based on four hours per week of theoretical lectures together with the resolution of some practical exercises which are previously proposed to be evaluated after their resolution and submission.

Bibliography:

- *"Hidrología Subterránea", Custodio, E., Llamas, M.R., Editorial Omega, S.A., 1983*
- *"Hydrology for engineers", Linsley, Kohler and Paulhus, McGraw-Hill, Inc., 1982*
- *"Engineering Hydrology ", Subramanya K., Tata, McGraw-Hill, 1994*
- *"Hidrología Aplicada", Ven Te Chow, D.R. Maidment and L.W. Mays, McGraw-Hill, 1994*

Assessment:

The final mark of the subject will be obtained from the marks obtained in the exams of the subject.

Personal Tutorials:

The lecturers will post the tutorial timetable at the beginning of the academic course.

Additional Information:

This subject is the continuation of Hydraulics and Hydrology I. For this reason it is recommended to have attended it previously. Moreover it is advisable that the students had attended or are attending the subjects of Statistics and Numerical Calculus.

Syllabus:

1. INTRODUCTION

Presentation of the subject. Contents. Objectives. Evaluation. Bibliography. Teaching organization. Relation with other subjects. Applications in the field of Civil Engineering. Hydrologic cycle: components and flows. Statistics of world, national and Galician balances.

2. THE COMPONENTS OF HYDROLOGIC CYCLE

Hydrometeorology. Precipitation. Interception and surface retention. Surface runoff. Infiltration. Evaporation and transpiration. Subsurface and subterranean flow.

3. HYDROLOGIC BALANCES

Expression of balance. Types of balance. Global and by components balances. Balances of humidity in the soil. Balances in rivers, lakes and reservoirs. Balances in aquifers.

4. SURFACE RUN-OFF AND HYDROGRAPHS

Hydrographs: types in function of the size of the basin and parts of the hydrograph. Calculation of hydrographs: rational method, method of unitary hydrograph. Transmission of hydrographs. Capacity: methods of measurement and seasons of capacity: analysis of capacity, characteristic volumes of flow and classification of volumes of flows.

5. ANALYSIS OF EXTREME EVENTS. FLOOD AND DRY PERIODS

Floods: causes and types. Methods of study: empirical, hydrologic and statistical. Dry periods: methods of study.

6. SUBTERRANEAN HYDROLOGY

Basic principles of flow through land: Darcy's Law and equation of continuity. Hydrodynamic parameters. General equation of the flow. Application to studies of filtration. Flow in aquifers. Types of aquifers. Hydraulics of uptakes.

7. HYDROUS RESOURCES: EVALUATION AND USES OF WATER

Surface resources. Evaluation of resources and subterranean reserves. Available resources. Necessity of works of regulation. Regulation: methods of study. Concepts of guarantee and vulnerability. Problems associated with the exploitation of subterranean waters. Overexploitation. Combined use of surface and subterranean waters.

8. QUALITY AND CONTAMINATION OF WATERS

Natural quality of river and aquifers water. Contamination: types of contaminants and their problems. Regeneration. Prevention of contamination.

9. APPLICATIONS OF HYDROLOGY IN CIVIL ENGINEERING

Evaluation of hydrous resources for different uses. Dimensioning of civil works (dams). Studies of stability of works. Works of surface and subterranean drainage. Flow through tunnels.

10. HYDROLOGY IN GALICIA AND SPAIN

Hydrological planning. Hydrological plans. Available hydrous resources. Uses of water. Principal hydrologic problems. Floods. Dry periods. Environmental hydrologic problems. Wetness. Contamination of hydrous resources.

3.1.7.4. FOURTH YEAR

Reinforced and Prestressed Concrete

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Fernando Martínez Abella**
OTHER LECTURERS:	**Cristina Vázquez Herrero, Manuel F. Herrador Barrios**
YEAR:	**4th**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 7 EC**

Aims:

To teach fundamentals of the behaviour of reinforced and prestressed concrete structures, and to provide a basis for the student to design, build and maintain this type of structures.

Teaching Organization:

There are three lectures per week, dedicated to theory and practice. In addition, construction site visits will be organised, and laboratory practices will be developed in the Construction Engineering Laboratory and the CITEEC.

Bibliography:

- *"Hormigón Armado y Pretensado I", Murcia, J., Aguado, A. y Marí, A.R., Edicions UPC, Barcelona, 1993.*
- *"Hormigón Armado". 14ª Edición basada en la EHE, ajustada al Código Modelo y al Eurocódigo. Jiménez, P., García, A. y Morán, F., Gustavo Gili, Barcelona, 2000.*
- *"EHE Instrucción de Hormigón Estructural", Ministerio de Fomento, Madrid, 1999.*
- *"Design of Prestressed Concrete Structures", Lin, T.Y., Burns, N.H., John Wiley & Sons, New York, 1981.*
- *"Hormigón armado y pretensado. Ejercicios", Marí, A.R., Aguado, A., Agulló, L., Martínez, F., Cobo, D., Edicions UPC, Colección Politext, Barcelona, 1999.*
- *"Proyecto y cálculo de estructuras de hormigón ", Tomos I y II, Calavera,J., Intemac, 1999.*
- *"La EHE explicada por sus autores". Coordinador de la obra: Garrido, A., Leynfor, Madrid, 1999.*
- *"Prestress concrete analysis and design", Naaman, A., McGraw-Hill, 1982.*
- *"Prestress concrete basics", Collins y Mitchel, Canadian PCI, 1987.*
- *"Manual de Aplicación de la EHE. Materiales-ejecución-control (Comentado)", Garrido, A., Leynfor, Madrid, 1999.*

Assessment:

During the course, some practices are set for the students, which are necessary to pass the subject, besides laboratory practices. Two assessment exams are held during the course. If any of the partial exams is not passed, the final examination will take place in June and September. Once the examination is passed, practices will be taken into account for the final marks.

Personal Tutorials:

They will be posted at the beginning of the course.

Additional Information:

To take this course, the student must have studied the following subjects: Construction Materials and Structures I and II.

Syllabus:

1. **INTRODUCTION**
   Introduction to reinforced and prestressed concrete. History and applications. Advantages and disadvantages of concrete structures.

2. **REINFORCED AND PRESTRESSED CONCRETE STRUCTURES PROJECT**
   2.1. Fundamentals of design: Limit States Theory, Loads and their Combinations, Materials, Durability, Structural Analysis of Prestress, Prestressing Force and Prestress Losses, Sectional Analysis, Introduction to Analysis of B and D zones: Strut-and-Tie Models. **2.2. Limit States**: Ultimate Limit State-Equilibrium, Prestress Design, Ultimate Limit Flexural State, Ultimate Limit State of Tangential Stresses-Shear, Ultimate Limit State of Tangential Stresses-Torsion, Ultimate Limit State-Buckling, Ultimate Limit State-Anchorage, Service Limit State-Cracking, Service Limit State-Deformation, Deflection Calculation. **2.3. Project criteria**: Usual Cross Sections, "T" Shaped Sections, Special Structures, Reinforcement Detailing, Pre-design Criteria.

3. **STRUCTURAL ELEMENTS**
   Building concrete floors, Foundations, Walls, Bulk concrete elements.

4. **STRUCTURAL CONCRETE CONSTRUCTION**
   Components of concrete, Reinforcement, Prestress Technology, Execution, Admissible errors, Quality Control.

5. **SUMMARY**

Environmental Engineering

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Joaquín Suárez López**
OTHER LECTURERS:	**Alfredo Jácome Burgos and Estrella Rodríguez Justo**
YEAR:	**4th**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 7 EC**

Aims:

To know, understand and apply technology to solve problems related with urban solid wastes, atmosphere and sound pollution and the relationships between quality and water contamination as well as designing the water supply and sewage systems of a population.

Teaching Organization:

For 3 hours a week theoretical lectures are imparted and the problems proposed in the lectures are solved. Laboratory practices and computer practices will be carried out. The student will do a course project.

Bibliography:

- *"Manual técnico del agua", DEGREMONT, Cuarta edición, 1979.*
- *"Depuración de aguas residuales", Hernández, A., Colegio I.C.C.P., Madrid, 1990..*
- *"Abastecimiento y distribución de aguas", Hernández, A., Colegio I.C.C.P., Madrid, 1990.*
- *"Ingeniería Sanitaria: tratamiento, evacuación y reutilización de aguas", Metcalf- Hedí, McGraw- Hill; 1995.*
- *"Abastecimiento de agua y alcantarillado", Steel, E.W. and McGhee, T., Gustavo Gili, Barcelona, 1981.*
- *" Introducción a la Ingeniería Sanitaria y Ambiental", Tejero, I., Suárez, J., E.T.S. de Ing. de Caminos de La Coruña y Santander, 1995..*

Assessment:

In order to pass the course it is necessary that the coursework and the laboratory classes have been completed. Two partial examinations will be set besides the final exams of June and September. To pass the course the two assessment examinations must be passed (8 marks) and the marks of the coursework and practice work are taken into account (2 marks).

Personal Tutorials:

In working hours. In examination time a specific timetable is posted. In days previous to the exams a voluntary seminar on resolved queries will be held.

Additional Information:

It is assumed that the students know the basic concepts of chemistry and hydraulics.

Syllabus:

1. SANITARY AND ENVIRONMENTAL ENGINEERING: ORIGIN AND EVOLUTION.
2. ENVIRONMENTAL PROBLEMS. ENVIRONMENTAL MANAGEMENT.
3. ECOLOGY AND MICROBIOLOGY. BASIC CONCEPTS
4. PUBLIC HEALTH. HUMAN DEMOGRAPHY
5. DIRT AND URBAN WASTES
6. SOLID URBAN WASTES. COLLECTION AND TRANSPORT
7. SOLID URBAN WASTES. TREATMENT AND/OR REMOVAL.
8. ATMOSPHERE AND SOUND POLLUTION.
9. WATER MANAGEMENT.
10. NATURAL WATER.
11. WATER POLLUTION. WASTE WATERS.
12. WATER QUALITY. ITS CONTROL
13. WATER QUALITY IN RIVERS. SELF- PURIFICATION
14. POLLUTION OF LAKES. RESERVOIRS AND AQUIFERS.
15. DUMPING URBAN WASTES IN THE SEA.
16. COLLECTING, PIPES AND PUMPS FOR WATER SUPPLY.
17. STORAGE AND MEASURING OF WATER.
18. TREATMENT OF WATER SUPPLY: FREE DECANTATION
19. COAGULATION- FLOCCULATION
20. DECANTING. SPECIAL SETTLING TANKS
21. FILTERING
22. RAPID FILTERING
23. DISINFECTING, CHLORINATING, OZONATION
24. SPECIAL TREATMENTS
25. WATER DISTRIBUTION NETWORKS
26. DRAINS NETWORK
27. PURIFYING WASTEWATER
28. PRETREATMENT
29. PRIMARY TREATMENTS
30. BIOLOGICAL TREATMENTS. BASICS
31. BACTERIAL BEDS
32. ACTIVE SLUDGES
33. TREATMENT AND REMOVAL OF SLUDGES. THICKENING
34. STABILIZATION OF SLUDGES
35. DEHYDRATATION AND REMOVAL OF SLUDGES
36. PURIFYING OF A.R.U OF SMALL COMMUNITIES
37. NATURAL PURIFYING. RE- USE OF WATER
38. ENVIRONMENTAL IMPACT

Harbours and Coasts

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Juan R. Acinas García**
OTHER LECTURERS:	**Ricardo Babío Arcay**
YEAR:	**4th**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 7 EC**

Aims:

To acquire the basic knowledge and capacities which deal with the area of Harbours and Coasts. To understand the dynamic phenomena involved in the oceanic, atmospheric and coastal environment. To give response to the problems that the shore, harbours and coasts pose in Civil Engineering. To know the actions of engineering upon the shore, as well as their impact in the environment, especially on the sea shore.

Teaching Organization:

During three hours a week lectures will be made up of theory and will outline and solve examples aiming to achieve the participation of the student. Different applications will be proposed which will form the coursework.

Bibliography:

- *"Coastal Engineering", HORIKAWA, K., 1978. Univ. of Tokyo Press.*
- *"Coastal Meteorology", HSU, S.A., 1988. Academic Press.*
- *"Coastal, Estuarial and Harbour Engineers´ Reference Book", ABBOTT, M.B. & PRICE, W.A., 1994. E & FN Spon.*
- *"Meteorología Dinámica. Clima de las costas españolas", ACINAS, J. R., 1997, Universidade da Coruña. Tórculo A.G., A Coruña.*
- *"Port Engineering. 2 Vols", Bruun P., Gulf Publishing Co, 1973-1989.*
- *"Recomendaciones para obras marítimas", FOMENTO, 1990, ... Puertos del Estado.*
- *"Shore Protection Manual", CERC, Coastal Engineering Research Center, 1984, U.S. Army Corps of Engrs. U. S. Govt. Printing Office, 2 Vols.*
- *"Water wave Mechanics for Engineers and Scientists". DEAN, R.G. & DALRYPLE, R.A., 1984. World Scientific, Advanced Series in Ocean Engineering.*
- *"Wind waves. Their generation and propaga tion on the ocean surface", KINSMAN, B., 1965. Prentice Hall.*

Assessment:

It is recommended that coursework be carried out. There will be two partial exams during the year apart from the final ones in July and September. To pass 'by course' it is required to obtain a minimum mark in each exam, moreover, the coursework mark will be taken into account.

Personal Tutorials:

During working hours. In the exam period a specific time-table will be posted.

Additional Information:

It is assumed that the students have taken the subjects corresponding to the third course. In addition, it is recommended to attend this subject before any others in the field of Harbours and Coasts.

Syllabus:

1. **INTRODUCTION TO THE ENGINEERING OF HARBOURS AND COASTS**
2. **GENERAL ATMOSPHERIC-OCEANIC DYNAMIC. MARITIME CLIMATE**
3. **COASTAL ENVIRONMENT AND LITTORAL GEOMORPHOLOGY**
4. **WAVES. DESCRIPTION, GENERATION AND PROPAGATION**
5. **LONG PERIOD WAVES. TIDES AND CURRENTS**
6. **LITTORAL PROCESSES. THE BEHAVIOR OF BEACHES**
7. **BAYS AND ESTUARIES.**
8. **HARBOURS. FUNCTIONS. USERS. TYPOLO GIES.**
9. **COASTAL ENGINEERING STRUCTURES**
10. **COASTAL PROTECTION, PLANIFICATION AND MANAGEMENT**

Roads and Airports

DEPARTMENT:	**Mathematical and Representation Methods.**
LECTURER IN CHARGE:	**Ignacio Pérez Pérez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- month Compulsory**
CREDITS:	**5 hours per week. 7.5 CC. 5.5 EC.**

Aims:

To know the problem areas of design and construction of the different elements of a road. The subject can be considered to be focused on the following blocks: 1) design of a cross section and analysis of the capacity of a road, 2) project and construction of explanations, 3) the lay-out of the road, and 4) the planning of flexible road surfaces and their construction processes.

Teaching Organization:

In the five hours per week of lectures the theoretical aspects are given and the practical exercises are set in the themes being dealt with. In parallel, the laboratory practical lectures are held referring to the fundamental tests explained in the theoretical lectures.

Bibliography:

- *"Normativa vigente del Ministerio de Fomento", Instrucción de carreteras, PG- 3/75 modificado, Instrucción de drenaje 5.2.I.C.*
- *"Colección de libros: Tráfico, explanaciones y drenajes, trazado de carreteras, y firmes", Kraemer C., E.T.S. de Ingenieros de Caminos de Madrid.*
- *"Ingeniería de Tráfico". Antonio Valdés.*
- *"Manual de Capacidad de Carreteras". Asociación técnica de carreteras. Comité español de la A.I.P.C.R.*
- *"Control de calidad en obras de carreteras", Ignacio Morilla Abad..*
- *Revistas "CEDEX" y "Carreteras"..*

Assessment:

The evaluation of the subject is carried out by means of a final exam, and the participation in the lectures is taken into account as well as the submitting of the practical exercises.

Personal Tutorials:

The lecturers set the times of weekly tutorials, in mutual agreement with the students.

Additional Information:

Knowledge of construction materials is assumed (cements, aggregates, asphalts, etc.) as well as the methods of proportioning of granular materials (granulometrics and adjustment by Fuller and Bolomey).

Syllabus:

1. **TRAFFIC ENGINEERING**
   Road transport. Vehicles. Movement of vehicles. Interaction between wheel and pavement. The driver and the pedestrian. The road networks and their elements. Characteristics of traffic. Planning and lay-out of roads. Traffic studies. Inventory of roads. Methods of forecasting the demand. Capacity and levels of service.

2. **LAY-OUT OF ROADS**
   Fundamental parameters . The ground plan lay- out: straight alignments, circular and transition curves. The elevated lay-out . General recommendations for the lay-out and its integration in the surrounding area. The transversal section.

3. **EARTHWORKS AND DRAINAGE**
   Geotechnical problems in roads. Studies and geological and geotechnical knowledge. Classification and characteristics of soils. Compacting of soils. Constructions of earthworks: previous operations; starting mechanisms, load and unloading; embankments. Load bearing capacity of the raised areas. Surface drainage. Subterranean drainage and geotextiles.

4. **ROAD SURFACES**
   Constitution and general concepts. Aggregates. Hydrocarbon binders. Granular layers. Stabilization of soils and treated gravel. Surface treatments: sprinklers and bitumen grout. Bitumen mixes. Concrete flooring. Road surface dimensioning. Surface characteristics of the flooring. Preservation.

Electrical Engineering

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Luis Montenegro Pérez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

To know the principles of electricity and electromagnetism with the aim of comprehending the functioning of the electric machines and applying them to the calculation of the aforementioned.

Teaching Organisation:

4 hours per week theoretical lectures are held and practical exercises previously given are resolved.

Bibliography:

- *"Electromagnetismo y circuitoe Eléctricos", Fraile, J., Servicio de publicaciones, U.P.M, Madrid, 1990..*
- *"Teoría de Circuitos. Fundamentos", Ras, E., Marcombo, S.A., 1998..*
- *"Teoría y Problemas de Circuitos eéctricos", Edminister, J. A., Mc Graw- Hill, New York, 1990..*
- *"Curso Moderno de Máquinas eléctricas rotativas", Cortes, M., Editores Técnicos Asociados, S.A., Barcelona, 1970..*
- *"Transformadores de potencia, de medida y de protección", Ras, E., Marcombo, S.A. 1985.*

Assessment:

To pass a final exam held in February or another in September. In addition, the lecture participation is evaluated continuously and taken into account.

Personal Tutorials:

During working hours . During the examination period a specific timetable will be posted.

Additional Information:

It is assumed that the students know the basic principles of electro - statics and magneto- statics. See the subject of Applied Physics of the first course.

Syllabus:

1. **BASIC CONCEPTS**
   Concept of power load. Concept of electric current: Intensity. Concept of electric field: Coulomb's law. Concept of magnetic field. Superimposition of field. Lorenzt's force.

2. **LAWS OF ELECTROMAGNETISM**
   Gauss' Law, Law of induction, Ampere-Maxwell's Law and the divergence of induction field.

3. **STATIONARY ELECTRIC CURRENT**
   Concept of electrostatic potential. Concept of electromotive force. Ohm's Law. Concept of electric resistance. Concept of magnetic induction field. Joule effect, concept of power and energy.

4. **CIRCUITS WITH CONTINUOUS CURRENT**
   Kirchhoff's Law. Maxwell's Rule. Equivalent systems. Resistances in series, in parallel and in triangle. Thévenin and Norton's Theorems. Measuring devices.

5. **MAGNET0- STATICS**
   Magnetic field created by a rectilinear current. Field created by a toroidal solenoid. Concept of Magnetisation. Concept of magnetic field H. Magnetic field H in a toroidal nucleus. Magnetic susceptibility and permeability.

6. **ALTERNATING CURRENTS**
   Principles: electromagnetic induction; concept of autoinduction; mutual induction; magnetic energy; hysterisis. Elements: concept of alternative current; maximum, medium and mean-square values; complex magnitudes; concept of phasor; concept of condensor; virtual resistance of an autoinduction, of a condenser and of a resistance.

7. **NETWORKS WITH ALTERNATING CURRENT**
   Virtual resistances in series. Virtual resistences in parallel. Kirchhoff's Laws in alternative current. Concept of resonance. Power and power factor.

8. **TRIPHASIC SYSTEMS**
   Generation of triphasic currents. Y- Delta connection. Y- delta conversion. Unbalanced power loads. Power in triphasic systems. Means of power. Transport of energy: advantages. Symmetric components.

9. **STATIC ELECTRIC MACHINES. TRANSFORMERS**
   Fundament of power transformers. Parts of a monophasic transformer. Nominal power of a transformer. Current of excitation or of vacuum in the transformer. Transformer in power load. Equivalent Scheme of the transformer. Trial of the transformer in short- current. Losses and performances in a transformer. Work in parallel of monophasic transformers. Connections in the triphasic transformers.

10. **ELECTRIC MACHINE DYNAMICS**
    Fundamental principles. Electromagnetic converters. Rotational machines: magnetic systems, electric systems. Classification of the machines. Losses, performance and warming up in electric machines. Machines in continuous current. Synchronous machines: Characteristics. Asynchronous machines: Characteristics. Electromechanic conversion: Engines and turbines: Connection to electric machine dynamics.

11. **NORMATIVE AND CLASSIFICATION OF INSTALLATIONS**
    Defects in installations. Calculation of the cable section for maximum fall of tension. Elements of manoeuvre Elements of protection.

12. **GENERATION OF ELECTRIC ENERGY**
    Coal power stations. Nuclear power stations. Power stations based on alternative energies. Hydroelectric power stations. Spanish electric market.

Steel Structures and Combined Construction

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Santiago Hernández**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**5 hours per week. 7.5 CC. 5.5 EC.**

Aims:

To know and to understand the resistant behavior of steel and combined structures, applying it to the dimensioning and design of those, following the existing regulations.

Teaching Organisation:

For 5 hours a week theoretical lectures are held and exercises are resolved based on the theoretical aspects explained. The students must carry out a coursework consisting of the study of a real structure.

Bibliography:

- *"Curso de estructuras de acero", S. Hernández Ibáñez, ULC, ETSICCPC.*
- *"Ejercicios de estructuras de acero", S. Hernández, J. Doria, L.E. Romera ULC, ETSICCPC.*
- *"Construcciones metálicas", V. Zignoli, Ed. Dossat.*
- *"Construcción mixta hormigón – acero", J. Martínez Calzón, J. Ortiz Herrera, Ed. Rueda, 1978..*
- *"Prontuario de estructuras metálicas", 3ª edición, CEDES, 1994.*
- *Normas: " MV-101 Acciones en la edificación", "MV-103 Cálculo de las estructuras de acero laminado en la edificación".*

Assessment:

Final exams are held in June and September.

Personal Tutorials:

During working hours.

Additional Information:

It is assumed that the students have followed the subjects of Structures I and Structures II.

Syllabus:

1. **GENERAL CONCEPTS**
   Historical origins. Current situation and trends. Processes of fabrication. Series of profiles. Technical documentation.

2. **LIMIT STATE (L. S)**
   L. S. tests of ductile breaking: criteria of plastification. L.S. with dynamic loads: variable actions, resonance, impact, band actions. L.S. of fatigue. Wolher curve: Miner's rule: accumulated damage; accidental fatigue.

3. **ENVELOPING SURROUNDINGS, LOADS AND CLASSIFICATION OF ACTIONS**
   Lines of influence and enveloping surroundings of forces. Determinist, semi and probabilist criteria. Types and combination of actions. Spanish regulations. Hy pothesis and coefficients of loads. Regulation MV-101 and seismic regulation P.G. S. 2.

4. **STRAIGHT PIECES IN FLEXION, TRACTION/ COMPRESSION AND TORSION**
   Flexion: distribution of tensions: open and closed sections; CEC; calculation of sections: testing the transversal section; tensions and displacements; light beams. Buckling: Euler's theory. Compression and bending; buckling anelastic buckling; great deformations: influence of shear force; calculation of sections and connections; types of pieces to traction: testing of resistance and thinness. Torsion: uniform torsion, buckling, solution in tensions; application to sections; calculation of movements: deformations, centre of torsion, study of buckling; non-uniform torsion: approximated solution; treatment of 'I' sections, regulation MV-103.

5. **LATERAL BUCKLING AND WEB BUCKLING**
   Elastic and inelastic lateral buckling . Energy formulation. Rule MV- 103. Buckling and sheets solicited by axial and shear forces. Buckling of compressed wings. Web buckling in plain web beams: reinforced beams; stiffeners.

6. **MEANS OF LINKING**
   Evolution. Materials. Methods and associated coactions. Calculation of screwed joints: solicitations to shear and traction; linking by rivets and TAR: linking by ordinary and calibrated screws; dimensioned. Welding: methods of execution, types of electrodes, calculation of flat and spatial linking. Bases of piles.

7. **DEFINITION OF COMBINED STRUCTURE: CONCRETE AND STEEL**
   Use. Basic hypothesis. Concrete: diagrams; elastic and deferred deformations: b reaking criteria: limit values: flowage; relaxation and retraction. Steel: diagrams; structural steel, passive reinforcement, prestressing reinforcement and connection reinforcement.

8. **NORMAL LOADS (AXIL AND FLECTOR) AND TRANSVERSALS (SHEARING, TORSION AND CONNECTION)**
   Methods of calculation: ideal section, distributed forces. Instantaneous and deferred analysis. Analysis of rate of cracking. Thermal analysis. Mixed prestressed sections: isostatic prestressed and post connection. Momentum-curvature diagrams and of M-N interaction. Shear stresses. Gradient . Lines of shearing. Module of torsion. Box sections. Connections. Transversal reinforced concrete in slabs. Shear stress in exhaustion. Ultimate grazing. Interaction M-N-V. Crush of webs. Anelastic calculation of the connection and slab grazing.

9. METHODS OF CALCULATION, PREDIMENSIONED AND CONNECTIONS
   Lineals: reduced sections and methods based on constant types 0, 1 and 2 ; methods of the ELU and ELS. Non-lineals: elastoplastic analysis by momentum- curvature diagram; plastic analysis by joints (interaction M-N-V and types of sections). Construction processes. Imperfections and local buckling. Predimensioning. Partial sections of concrete. Stability in mounting. Practical dispositions of joints. Rigid, flexib le and slipping conections; elastic analysis and in EL.

Hydraulic Works

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Jerónimo Puertas Agudo and Rodrigo del Hoyo Fernández- Gago**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know the necessity of regulation and lamination of the contributions, the project and dimensioning of hydraulic conductions. To make an introduction to the study of dams and hydroelectric exploitation, irrigated land and fluvial works. To introduce themes of fluvial hydraulics and the restoration of fluvial beds.

Teaching Organisation:

4 hours a week of theoretical lectures are held where practical exercises previously posed are also solved.

Bibliography:

- *"Centrales Hidroeléctricas", Ediciones Paraninfo.*
- *"Apuntes de Obras Hidráulicas", E. T. S. Ing. Caminos. Madrid.*
- *"Selecting Hydraulic Reaction Turbines". U.S. Bureau of Reclamation.*
- *"Tratado Básico de Presas", E. Vallarino. Colegio de Ingenieros de Caminos.*
- *"Saltos de Agua y Presas de Embalse", Gómez Navarro.*
- *"Transitorios y oscilaciones en sistemas hidráulicos a presión", Abreu et al., U.P. Valencia..*
- *"Aprovechamientos Hidroeléctricos", E. Vallarino, L. Cueva,. Colegio de Ingenieros de Caminos.*
- *"Hidráulica Fluvial", J. P. Martín Vida, UPC, Politext.*
- *"HEC- RAS" Manual de Hidráulica.*
- *"Restauración de Ríos y Riberas", M. González del Tanago. ETS 1. Montes, UPM.*

Assessment:

To pass it is necessary to do the coursework. Final exams are held in June and September.

Personal Tutorials:

Two afternoons a week; they will be indicated at the beginning of the course.

Additional Information:

Syllabus:

1. **HYDRAULIC RESOURCES**
   Use of water. Regulation and lamination. The need for reservoirs.

2. **PIPES**
   A) Design of pressure pipes. B) Appliances to relieve the water hammer. C) Design of open channel conductions. D) Dissipation of energy. E) Protection of margins. F) Impact of the pipes. G) Irrigation pipes.

3. **INTRODUCTION TO THE STUDY OF DAMS**
   A) Typology. Previous studies: Locking and the vessel. Loads which act on the damp. Study of Floods. B) Brickwork Dams. Gravity dams. Light gravity dams. Arch dams C) Earth Dams: Homogeneous dams and core dams. Upstream baffle dams . D) Spillways and Outlets. Types of Spillways. Deep outlets. Gates and valves. E)Construction. Diverting the river. Construction methods of brickwork and earth dams. F) Exploitation and auscultation.

4. **HYDROELECTRIC EXPLOITATION**
   A) Electric energy. Power Stations. Hydroelectric Power Statios. B) Turbines and Elements of Power Stations. Design. C) Intakes and outlets. Devices of opening and closing. D) Hydroelectric study of basins.

5. **FLUVIAL HYDRAULICS AND RESTORATION OF RIVERS.**
   A) Fluvial morphology. B) Channelling. C) Hydraulics of bridges. D) Ecological discharge. E) Access mechanisms for fish.

3.1.7.5. FIFTH YEAR

Projects and Works Organization and Management

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**César García Cordovilla**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Compulsory Annual**
CREDITS:	**3 hours per week. 9 CC. 6 EC**

Aims:

To understand that the project planner, abided by multiple conditions (of technical, legal and property character), faced with a certain problem must provide with valid alternatives, choose the optimum one and bring it to fruition, foreseeing the problems of its construction. To know the technical, economic and legal framework, as well as the construction and planning processes of the works.

Teaching Organization:

For three hours weekly classes in theory are given and practical exercises resolved. During the course five visits will be carried out to installations of nearby works. Three conferences will be held. At the same time, the students should carry out a course project on a construction topic. Complementary activity: practical exercise trip.

Bibliography:

- *"Guía metodológica y práctica de proyectos", Morilla Abad I. ETSICCP, Madrid.*
- *"Manual de gestión de las obras de contratación pública", Rubio González A.*
- *"Manual de Contratos del Estado", García Ortega P.*
- *"La ejecución del contrato de obra pública", Juristo R..*
- *"Contratos del Estado: Dirección de obras", Menéndez Gómez E.*
- *"Manual del contratista de Obras Públicas", Viader A.*
- *"Movimiento de tierras: utilización de la maquinaria. Producciones y casos prácticos. Compactación de materiales y utilización de compactadores". Titkin J., ETSICCP, Madrid.*
- *Procesamiento de áridos: Instalaciones de hormigonado. Puesta en obra de hormigón", Titkin J., ETSICCP, Madrid.*

Assessment:

Two partial exams besides the final exams of June and September. To pass the course it is necessary to obtain a minimum mark in each partial exam and to have carried out the practical parts and the course work, these being taken into account in the final marks.

Personal Tutorials:

A specific timetable is posted at the beginning of the course.

Additional Information:

Syllabus:

1. PRELIMINARY ASPECTS TO THE DRAWING UP OF A PROJECT

The project: concept, general principles, types, project cycle and entities implicated, its assignment. Technical especifications, technical regulations and administrative clauses. Types of contracts. Technical and legal rules concerning the drawing up projects. Compiling of information and carrying out of previous studies. Economic analysis.

2. DRAWING UP THE PROJECT. ITS PROCESSING

Project documents. Works program. Plans. Regulation Papers. Particular Techniques. Budget. Studies of safety and hygiene in the work and studies of environmental impact. Specificities of urbanism projects. Processing.

3. THE PROJECT PLANNERS FIELD

The *Colegio de Ingenieros de Caminos, Canales y Puertos* (Institution of Civil Engineers). Ends and functions. *Visado* ('Approval') and professional civil responsibility. Professional jurisdiction. The Consultancy Firms.

4. ASPECTS PRIOR TO THE CONTRACTING OF WORKS

Legal definition of the work. Contract law of public administrations. Necessary requisites for holding the contract. Particular administrative clause papers. Guarantees and classification of the contractor. Revision of prices. Proceedings and forms for adjudicating the contract of works.

5. DEVELOPMENT OF THE CONTRACT OF WORKS

Actions prior to the commencement of the works. The management of the work. Beginning and normal development of contract of works. Activities. Influences on its development. Expiration of the contract. Private contracts of works.

6. THE CONSTRUCTION INDUSTRY

The construction sector and the professional activities of the Road Engineer. The Construction company. Studies prior to the contracting of works.

7. TECHNICAL-ECONOMIC PLANNING AND CONTROL OF WORKS

Techniques of programming and control of the execution of the works. Programming and graphic control and by - critical - path control. Allocation and resource leveling.

8. INSTALLATIONS, ASSEMBLY AND AUXILIARY AIDS

Energy sources. The use of compressed air. Aids for land surveying and drilling. Water. Lifting machinery. Cables as auxiliary elements. Basic installations. Common auxiliary aids in the works.

9. PROCEEDINGS USED IN DIGGING OF EARTH

Functional description of the machinery. Work units in open air digging of earth. Valuation of the production. Execution by mechanical proceedings and by means of blasting. Choice of equipment. Drilling machinery. Tunnels.

10. FOUNDATION AND COMPACTING OF THE EARTH

Test drilling. Piles. Bulkheads. Earth compacting processes. Injection of concrete mortar. Strata bolting. reinforced earth.

11. LIFTING AND TRANSPORT PROCESSES. AGGREGATES AND CONCRETE

Cranes. Exploitation of quarries. Installations for the fabrication of classified aggregates: crushing, transport, classification and storage. Installations and auxiliary machinery in the execution of concrete works; auxiliary aids for its setting up. Launcher beams.

12. PLANNING OF SPECIFIC WORKS

Technical- economic aspects and construction proceedings: Case of a linear road work, of a hydraulic work and one of roads.

13. ENSURING QUALITY IN PROJECTS AND WORKS.

Building and Prefabrication

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Cristina Vázquez Herrero**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

Prefabrication: to know prefabricated elements typology, their main design criteria and production processes. Building: design, building and maintenance of buildings through knowledge of structure, detailing, finishes, installations and specific equipment for building construction.

Teaching Organization:

There are four lectures per week, dedicated to theory and practice. There are also lectures by building designers, and visits to construction sites and prefabrication plants.

Bibliography:

- *"Estructuras de edificación prefabricadas ", FIP-ATEP, Madrid, 1996.*
- *"Edificación con prefabricados de hormigón", Vaquero, J. et. al., Ieca, 1996.*
- *"Manual de ejemplos de Aplicación de la EHE a la Edificación", Ache Geho-Atep, Madrid, 2001*
- *"Proyecto y cálculo de estructuras de hormigón ", Tomos I y II, Calavera,J., Intemac, Madrid, 1999.*
- *Normas NTE, NBE/EF-96,NBE/CPI-96, NBE/CT-79, NBE/AE-88,...*
- *"PCI design handbook: precast and prestressed concrete ",5ª edición, PCI, Chicago, 1999.*
- *"Prefabrication with Concrete ", Bruggeling, A.S.G., Huygue, G.F., Balkema, Rotterdam, 1991.*
- *"PCI manual for the design of hollow core slabs", Buettner, D. R. ., Becker, R. J., PCI, Chicago, 1998.*
- *"Multi-storey precast concrete framed structures ", Elliott..*
- *"Bâtir ", R. Vittone, Lausanne Polytechniques et Universitaires Romandes, Lausanne, 1996.*

Assessment:

There are final examinations in June and September. To pass the subject it is necessary to have passed each part of the subject: building and prefabrication in the final examinations of June or September.

Personal Tutorials:

They will be posted at the beginning of the second semester.

Additional Information:

Students are assumed to have studied Structures I, Geothechnical Engineering II, Reinforced and Prestressed Concrete, Steel Structures and Combined Construction.

Syllabus:

A. PREFABRICATION

A1. INTRODUCTION
Historical review. Scopes. Applications. Procedures. Standardisation and dimensional co-ordination. Production, transport and erection.

A2. BUILDING PREFABRICATION
General Criteria. Stability of structures under horizontal loads. Connections. Structural prefabricated systems used in building. Prefabricated framed building structures. Prefabricated building structures with panelled walls. Prefabricated floors. Standards and recommendations. Progressive collapse and resistance to accidental loads. Prefabricated façades.

A3. BRIDGE PREFABRICATION
Historical review. Typologies and procedures. Formal and aesthetic aspects. Usual procedures in bridges prefabrication. Singular construction procedures in bridges prefabrication.

A4. OTHER PREFABRICATED ELEMENTS

B. BUILDING

B1. INTRODUCTION AND PREVIOUS WORKS
The activity of the Civil Engineer in Building. Some aesthetic and environmental aspects. Previous determining factors: urban planning and Sea-shores, Water and Roads legislation. Usual parameters controlled by Planning. The objectives of the project.

B2. PREPARATION OF TERRAIN. FOUNDATION.
Field inspection. Surveying. Ground previous jobs: demolitions and excavations. Ground support. Criteria to choose the foundation system. Allowable settlements. Footings and basement walls.

B3. STRUCTURES
B3.1) Loads and their combinations. Fire resistance. Structural model. Design process. Results and detailing. Structural determining factors in building process. Security. Loads during construction. Strains in building structures. Customary building elements: beams, joists, supports, trimmed joists. Concrete floors: Beam-and-slab concrete floors, flat slab concrete floors, other concrete floors. Multifloor buildings. Structural systems. Structures lateral stiffening. Cutoff walls and cores. Framing interaction. Design methods. Singular buildings. Big span roofs. Spatial structures. Wooden structures. Introduction to structures pathology and rehabilitation. Diagnosis and corrective measures. Building rehabilitation.

B4. BUILDING ELEMENTS

Floors and pavements. Divisions and draw slates. Curtain walls. Inside and outside carpentry. Roofs and façades. Thermal and acoustic insulation. Building maintenance.

B5. INSTALLATIONS
Fire protection. Transport installations. Ventilation. Air conditioning. Plumbing. Electric installations. Other installations.

Transport Engineering

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Miguel D. Rodríguez Bugarín y Alfonso Orro Arcay**
OTHER LECTURERS:	**Margarita Novales Ordax**
YEAR:	**5th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

To explain the essential aims of Transport Engineering: Transport functions. Transport modes. Urban transport. Public services management. Transport demand. Transport costs. Transport infrastructures and services funding. Transport logistics.

Teaching Organization:

The theoretical lectures are carried out together with the resolving of some examples and practical problems.

Bibliography:

- *"Transportes. Un enfoque integral", Izquierdo, R. Publicaciones del Colegio de Ingenieros de Caminos, Madrid, 1994*
- *"Transportation Planning Handbook", AA. VV. Institute of Transportation Engineers. Prentice Hall, New Jersey, 1992.*
- *"Transportes", Ibeas, A., Díaz, J.M. Servicio de Publicaciones, E.T.S.I.C.C.P. Santander, 1998*.
- *"Sistemas de Transporte", Ruiz A., Publicaciones del Colegio de Ingenieros de Caminos, Madrid, 1995*
- *"Transportation and Traffic Engineering Handbook", AA. VV. Institute of Transportation Engineers. Prentice Hall, New Jersey, 1982.*

Assessment:

A final exam will be held, covering the whole contents of the subject.

Personal Tutorials:

At the beginning of the course lecturers will post their tutorial hours.

Additional Information:

Syllabus:

1. **TRANSPORT**
   Introduction. Transport Systems Characteristics and Functions. Transport and National Economy. Transport and Regional Development. Transport and Land Use. Transport and Economic System. Transport and the European Integration Process. Energy and Transport. Transport and Society System.

2. **HISTORICAL DEVELOPMENT OF THE SPANISH TRANSPORT SYSTEM**
   The Roman Rule.. The Middle Ages. The Modern Age. The 19th and 20th centuries. Shipping. Air Transport.

3. **TRANSPORT MODES**
   Highways. Rail Transport. Maritime Transport. Air Transport. Combined Transport.

4. **METROPOLITAN TRANSPORT**
   The Metropolitan Concept. Mobility. Urban Mass Transit Systems.

5. **PUBLIC TRANSPORT SERVICES MANAGEMENT**
   Management Systems. Direct Management. Indirect Management. Relationships between Public Administrations and Public Transport Carriers.

6. **CARRIERS MANAGEMENT**
   Carrier Enterprise Types. Management and Organizational Structure of Carriers. Highway Carriers Management. Railroad Carrier Management.

7. **TRANSPORT DEMAND**
   Demand concept. Current Demand Analysis. Potential Demand Analysis. Models.

8. **COSTS**
   Definitions. Costs Classification. Overview of Cost Models. Transport Modes Costs.

9. **INFRASTRUCTURES AND SERVICES FUNDING**
   Pricing and Rates Formation. Transport Taxation. Financing in the Private Services. Financing in the Public Services. Infrastructures Funding.

10. **TRANSPORT LOGISTICS**
    Introduction. Outbound Logistics (Physical Distribution). Logistics Companies. Logistics Centers. Logistics and Telematics.

Legislation

DEPARTMENT:	**Mathematic Methods and of Representation**
LECTURER IN CHARGE:	**Juan José Bértolo Cadenas**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**2 hours per week. 3 CC. 2 EC**

Aims:

To know, understand and apply the basic legislation necessary to develop the profession of Civil Engineer.

Teaching Organization:

Two hours weekly classes in theory are held and previously proposed practical questions are resolved.

Bibliography:

- *Aountes elaborados por el profesor y entregados en clase.*
- *"Curso de Derecho Administrativo I", García Enterría E, Fernández T.R., Ed. Civitas, Madrid, 1992.*
- *"Derecho Administrativo I (parte general)", Parada Vázquez R., . Ed. Marcial Pons, Madrid, 1993.*
- *"Derecho Administrativo (parte especial)", Bermejo Vera J., Ed. Civitas, Madrid, 1994.*

Assessment:

To pass it is necessary to carry out the course work. Exams are held at the end of June and September, and the marks of the coursework and practical work submitted are taken into account.

Personal Tutorials:

During working hours. During exam period a specific timetable will be posted.

Additional Information:

Each student is given the most important legal texts to use for a greater knowledge of the subject.

Syllabus:

1. CONSTITUTIONAL AND AUTONOMOUS LAW

1.- General considerations on constitutionalism in Spain. The Constitution of 1978. Characteristics, structure and contents. Fundamental rights and public liberties: Its guarantee and suspension. The Constitutional Tribunal. The reform of the Constitution. 2.- The different election systems. The Spanish electoral law. Application of d´Hont Law to the Spanish elections. 3.- The autonomous jurisdiction. The state laws within the framework of transference and delegation. 4.- Galician autonomy: origin and evolution. The Statute of Autonomy of Galicia: Structure and contents. Extension of state Law.

2. ADMINISTRATIVE LAW(GENERAL PART)

5.- The Constitution as juridicial law. The Law. Concept and types. Dispositions of the executive with force of law: Decrees and legislative decrees. 6.- The regulations: Concept and types. The limits of regulatory power. 7.- The administrative process: Concept and nature. The Legal System Law of the Public Administrations and Common Administrative Proceedings: ambit of application and principles. Phases of administrative processes: Initiation, distribution, instruction and termination. Administrative silence. The prior reclamations to the prosecution of civil and laboural actions. 8.- Administrative appeals: Concept and types. General requirements of administrative appeals. Appeal matters, legitimization and competent organ. Ordinary appeal and of review. Contentions- administrative appeal. 9.- Administrative contracts. Nature, characteristics and classes. Elements: Subject, object, cause and form. Forms of contract. 10.- Content and effects of administrative contracts. Fulfillment of administrative contracts. Risk fortune and acts of God in the administrative contracting. Revision of prices. Termination of contracts. Cession and subcontracting of administrative contracts. 11.-special reference to contract works. 12.- Force expropriation and powers of expropriation. Nature and justification. Subjects, object and cause. The expropriation process in general. Jurisdictional guarantees.

3. ADMINISTRATIVE LAW (PARTICULAR PART)

13.- Juridicial regime of roads. Classification of roads. Limitation of property. Autonomous jurisdiction. Roads of provincial ownership or other ownerships. 14.- Legal control of water. Limitations of property. Autonomous jurisdiction. The water management bodies. 15.- Legal control of the coasts. Limitations of property. Autonomous jurisdiction. Urban implications. 16.- Legal control of ports. Classifications of ports. Autonomous jurisdiction. Port Management bodies. 17.- Legal government of transport. The Law of Distribution of Land Transport and its Regulation. The Organic Law of Delegation of Faculties of the State in the Regional Communities. 18.- Legal government of the Atmosphere. The principle of he who pollutes must pay. Galician sectorial legislation: Tax Law for Pollution. 19.- Legal government of the land: Antecedents and current regulation. Urban government of the property of land. Instruments of planning. 20.- Systems of execution of the Planning. System of appraisments. 21.- Regional jurisdiction: Analysis of the sentence of the Constitutional Tribunal of 20th March 1997. Special reference to Galician urban legislation. 22.- Legal government of housing. Officially protected housing. Direct promotion and private promotion. Public management bodies of land and housing.

Regional and Urban Planning

DEPARTMENT:	**Architectural and Urban Projects**
LECTURER IN CHARGE:	**Carlos Nárdiz Ortiz**
OTHER LECTURERS:	**Juan Creus Andrade**
YEAR:	**5th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To introduce the student to the urban and territorial sense of infrastructures which an engineer projects, constructs and plans. To introduce the student to the theories, the techniques and the objectives of Urban Planning and Regional Organization.

Teaching Organization:

The course has a strong theoretical component derived from the syllabus and a practical component derived from the contrast between the diagnostic of the territorial reality and the possibilities of Urban Planning and Regional Planning. It is considered that in this sense that the subject at practical level be complemented with the subjects in the field: Urbanism II and Urban Services.

Bibliography:

- *"Atlas Histórico de Ciudades Europeas. Península Ibérica", Centro de Cultura Contemporánea de Barcelona 1994..*
- *"Galicia: Estructura del Territorio y Organización Comarcal", Andrés Precedo Ledo. Santiago, 1987..*
- *"Planteamiento Urbano en la España Contemporánea (1900-1980)".Fernando de Terán. Alianza Universidad Textos, Madrid, 1982.*
- *"Elementos de Ordenación Urbana", Juli Esteban i Noguera . Colegio de Arquitectos de Cataluña. Barcelona 1981.*
- *"Madrid. Región Metropolitana. Estrategia Territorial y Actuaciones", Comunidad de Madrid. Madrid, 1991*
- *"P1an Director de Infraestructuras 1993-2007", Publicaciones del MOPTMA, 1994.*

Assessment:

The assessment is based on two exercises on urban theory and another on the urban and regional reality, together with a final exam.

Personal Tutorials:

During working hours. Tutorials are established furthermore for practical exercises.

Additional Information:

The one derived from Planning or from the Distribution of the area in which the practical exercises are carried out.

Syllabus:

1. DISTRIBUTION OF THE REGION AND URBANISM. CONCEPT
2. THE PROCESS OF URBANIZATION OF THE REGION. THE FORMATION OF THE URBAN SYSTEM.
3. THE RURAL SETTLEMENTS
4. THE HISTORIC CENTRES
5. THE TRADITION OF BAROQUE AND MILITARY URBANISM.
6. THE TRADITION OF THE TECHNIQUES OF THE 19TH C. THE SUBURBS AND INTERIOR REFORM.
7. THE ORIGINS OF MODERN URBANISTIC THINKING.
8. THE CITY OF MODERN MOVEMENT.
9. THE ANALYSIS OF THE FORM OF URBAN GROWTH IN THE CURRENT CITY.
10. THE ANALYSIS OF URBAN ROADS IN THE CURRENT CITY.
11. THE RESPONSE OF URBANISTIC LEGISLATION. THE SYSTEM OF PLANNING IN SPAIN.
12. MUNICIPAL PLANNING. OBJECTIVES AND CONTENTS.
13. THE PROCESS OF ELABORATION OF MUNICIPAL PLANNING.
14. MUNICIPAL PLANNING IN GALICIA.
15. METROPOLITAN PLANNING.
16. TRANSPORT IN METROPOLITAN AREAS.
17. TERRITORIAL PLANNING.
18. THE URBAN SYSTEM AND THE PLANNING OF THE REGION.
19. THE INFRASTRUCTURES OF TRANSPORT AND OF REGIONAL DEVELOPMENT.
20. THE INFRASTRUCTURES AND THE ENVIRONMENT.
21. THE DISTRIBUTION OF THE PHYSICAL ENVIRONMENT.

Business Organization and Management

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Antonio Fernández Garitaonandía**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

It is expected that the student acquires the necessary knowledge from the moment a business is planned until it is working. This general aim is defined in the following points: a) a general idea about the firm and its strategy, b) a basic knowledge about accounting, c) organization, d) legal help, e) the system to be taken into account about staff, production and marketing, f) a follow-up of the financial situation in the firm, g) a financial position and analysis and h) to go into detail about the basic principles of the firm in the building sector.

Teaching Organization:

Theoretical lectures and practical exercises are solved for 4 hours per week.

Bibliography:

- *"Organización y Gestión de Empresas", Fernández Garitaonandía A., ETSICCP, A Coruña*
- *"Contabilidad para Dirección ", Pereira Soler F., Navarra University Publications, S.A., Pamplona*
- *"Mementos Prácticos: Sociedades Mercantiles, Fiscal y Social ", Francis Lefebvre Publications, Madrid*
- *Miscellaneous Texts from Deusto Publications, S.A., Madrid*

Assessment:

There are two final examinations: the first one in June and the second one in September.

Personal Tutorials:

A specific timetable is posted at the beginning of the course.

Additional Information:

Syllabus:

1. **BUSINESS ENTERPRISE**
2. **BUSINESS STRATEGY**
3. **STRUCTURE**
4. **ACCOUNTING**
5. **ANALYTIC ACCOUNTING**
6. **LEGAL SYSTEM**
7. **HUMAN FACTOR**
8. **PRODUCTION**
9. **MARKETING**
10. **QUALITY**
11. **MANAGEMENT**
12. **FINANCIAL ACCOUNTING**
13. **BALANCE SHEET**
14. **TRADE BOOKS**
15. **COLLECTION AND PAYMENT INSTRUMENTS**
16. **CURRENT ASSETS**
17. **FIXED ASSETS**
18. **LIABILITIES**
19. **INCOME STATEMENT**
20. **FINANCIAL ANALYSIS**

History of Civil Engineering

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Manuel Durán Fuentes**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Compulsory**
CREDITS:	**2 h per week. 3 CC. 2 CC**

Aims:

To find out about the history of Civil Engineering (public works in particular and constructions in general) so that this historic heritage is justly assessed, to study the process of calculus of the factories and to establish intervention criteria for the Historic Heritage of Public Works.

Teaching Organization:

For two hours per week in the first fourth - monthly period theoretical classes are held, with important visual back-up, in accordance with the syllabus of the subject.

Bibliography:

- *"Estructuras de fábrica",Jacques Heyman. Instituto Juan Herrera, ETS Arquitectura Madrid, 1995 .*
- *"A History of Civil Engineering", Hans Straub. Leonard Hill Ltd.,.London, 1952*
- *"Historia de las Obras Públicas en España", Ed. Turner, Colegio de I.C.C.P. Madrid, 1979*
- *" Historia de la Arquitectura", Spiro Kostof. Alianza Forma, Madrid, 1988.*
- *"Ingeniería Hidráulica romana", Carlos Fernández Casado. Ed. Turner, Colegio del I.C.C.P. Madrid, 1983..*
- *"Ciencia y Tecnología en la España Ilustrada", Antonio Rumeu de Armas. Ed. Turner, Coelgio de I.C.C.P. Madrid, 1980.*

Assessment:

The attendance to the lectures will be evaluated. The work carried out during the four-month period and the final exam marks will be taken into account.

Personal Tutorials:

They will be specified during the academic period.

Additional Information:

Syllabus:

1. **CIVIL ENGINEERS IN THE HISTORY OF EUROPE**
   The Greek and Roman architects. The "Collegi". The medieval masterbuilders and the guilds. Renaissance engineering. New techniques: military engineers. Separation of Architecture and Engineering. The civil engineers and the new polytechnic schools. The *Ingenieros de Caminos, Canales y Puertos*.

2. **HISTORY OF ARCHED STRUCTURES**
   The invention of the arch. The first arches. The arched Roman structures. The bridge in the history of construction. Roman bridges. Medieval bridges. Differences between the models constructed. Historic evolution of bridges since the Renaissance to the 20th Century. The great vaults and cupolas of European construction.

3. **HISTORIC EVOLUTION OF THE ROAD AND PORT INFRASTRUCTURES**
   The wheel and the road. The first road networks of the Levantine empires. The Roman road network. Construction techniques of the Roman roads. In "Hispania". The medieval roads. Construction techniques and layouts and the royal highways in the 18th Century. The train and the automobile. The new transport networks in the 19th and 20th centuries. Navigation history. The Greek ports and the great Roman ports. Historic evolution of port infrastructures up to the 20th Century.

4. **THE CITY: LAYOUT AND PUBLIC HEALTH NETWORKS**
   The Levantine, Greek and Roman city. The medieval European and Arab cities. The new implantation of cities in Latin America. The new populations of the Renaissance: new concept of the city. The health infrastructures: historic evolution up to the 18th Century. The urbanized city and the suburbs of the 19th and 20th Centuries.

5. **THE HISTORIC HERITAGE OF PUBLIC WORKS**
   History and restorations. Restoration, rehabilitation, consolidation. Basic criteria of intervention. Current legislation. Examples of interventions in other historic public works.

6. **ANALYSIS OF STONE- WORKS**
   Reading of parameters. Concept of stability. Historic development of the methods of analysis of stability. Graphic procedures and numerics of limit analysis .Elaboration of reports on load- bearing capacity of historic bridges.

End of Degree Project

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Pedro Sánchez Tamayo and Alfonso Orro Arcay**
OTHER LECTURERS:	**Margarita Novales Ordax**
YEAR:	**5th**
TYPE:	**Compulsory Annual**
CREDITS:	**6 CC. 6 EC**

Aims:

The End of Degree Project will consist of the carrying out and presentation, on the part of each student, of an original project which is connected to any of the fields which cover the profession *of Ingeniero de Caminos, Canales y Puertos*.

Teaching Organization:

The student will hand in to the responsible lecturers his proposal for the End of Degree Project for its approval. The lecturer, in agreement with each student, will establish a calendar of interviews along the course in which he will review the progress of the End of Degree Project.

Bibliography:

- It is handed in a *"Procedure for the execution of the End of Degree Project"* .

Assessment:

The project will be presented in the format established in the *" Regulation of the End of Degree Project*" of the School and the *"Procedure for the execution of the End of Degree Project*". The projects will consist of the corresponding Written Papers and Appendices, the Plans, the 'List of Particular Technical Orders' and the Budget. The evaluation of each End of Degree Project will be carried out by a examining board nominated to that task and formed by three lecturers of the School. In the public act of evaluation, the student will present his project; during the presentation the examining board will put forward questions which they consider necessary concerning the content of the project. Following this, the Tribunal will retire to deliberate and decide if the project is accepted or should be modified or amplified. Once all the projects presented in the period of presentation are evaluated the qualification of the End of Degree Project will be given.

Personal Tutorials:

A specific timetable will be published.

Additional Information:

3.1.7.6. OPTIONS

Dynamic Analysis of Structures

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Luis Esteban Romera Rodríguez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**Four hours per week. 6 CC. 4 EC.**

Aims:

To train the student in the topic of the most common dynamic loads which affect the structures. During the course they will study systems of one and several degrees of freedom, not only shock absorbing but also non-shock absorbing. Within the dynamic actions they will analyze the method of modal superimposition such as that of the response spectrum.

Teaching Organization:

Two hours of theory and two hours of practical lectures are held weekly. Part of these latter will consist of the resolution of structural models in a dynamic regime by means of computer programs.

Bibliography:

- *"Dynamic of Structures. Theory and Applications to Earthquake Engineering", CHOPA, ANIL K., Prentice Hall, 1995..*
- *"Structural Dynamics. Theory and Computations", PAZ, MARIO, Chapman may, 1997.*
- *"Constructions Vibrations.", DOWNING, CHARLES H., Prentice Hall, 1996.*
- *"Response Spectrum Method. In Seismic Analysis and Design of Structures.", GUPTA AJAYA K., CRC Press, 1990..*
- *"The Finite Element Meted. Linear Static and Dynamic Finite Element Analysis." HUGHES THOMAS J.R., Prentice Hall, 1987.*
- *"Ejemplos resueltos de cálculo matricial de estructuras con el programa SAP90.", JURADO ALBARRACÍN, J.A., HERNÁNDEZ IBÁÑEZ, S., Ediciones Tórculo, 1997.*
- *"Análisis estático y dinámico de estructuras con el programa COSMOS/M. ", ROMERA RODRÍGUEZ, L.E., HERNÁNDEZ IBÁÑEZ, S., Universidad de La Coruña, 1997.*

Assessment:

By means of course work and the end- of- the year exam, in the exam periods of June and September.

Personal Tutorials:

During working hours.

Additional Information:

The students must have a good knowledge of matrix analysis of structures and of the Finite Element Method applied to the analysis of structures.

Syllabus:

1. **INTRODUCTION AND FUNDAMENTAL CONCEPTS.**

SYSTEMS WITH ONE DEGREE OF FREEDOM

2. **RESPONSE TO FREE VIBRATIONS**
3. **RESPONSE TO HARMONIC AND PERIODIC FORCES**
4. **RESPONSE TO INCREMENTAL, PULSATING AND GENERAL FORCES.**
5. **EARTHQUAKES. GENERAL CONCEPTS AND ACTIONS ON THE STRUCTURES.**
6. **SEISMIC RESPONSE OF SYSTEMS WITH A DEGREE OF FREDOM.**
7. **NUMERICAL OBTAINING OF THE DYNAMIC RESPONSE.**

SYSTEMS WITH SEVERAL DEGREES OF FREEDOM.

8. **FORMULATION OF PROBLEMS AND EQUATIONS OF MOVEMENT.**
9. **NATURAL FREQUENCIES AND MODES OF VIBRATION.**
10. **METHODS OF OBTAINING OF THE MODES OF VIBRATION.**
11. **FORMULATION OF THE MATRIX OF SHOCK- ABSORPTION. TYPES OF SHOCK ABSORPTION.**
12. **LINEAL ANALYSIS OF SYSTEMS WITH SEVERAL DEGREES OF FREEDOM. DYNAMIC LOADS.**
13. **SEISMIC RESPONSE OF SYSTEMS WITH SEVERAL DEGREES OF FREEDOM, METHOD OF REDUCTION OF DEGREES OF FREEDOM.**
14. **METHODS OF EVALUATION OF THE SEISMIC RESPONSE: INTEGRATION IN TIME AND SPECTRUM OF RESPONSE.**
15. **SYSTEMS WITH MASS AND DISTRIBUTED ELECTRICITY. RESPONSE TO DYNAMIC LOADS.**
16. **SEISMIC RESPONSE OF SYSTEM WITH MASS AND DISTRIBUTED ELASTICITY.**

Special Foundations

DEPARTMENT: **Construction Technology**
LECTURER IN CHARGE:
OTHER LECTURERS:

YEAR: **5th**
TYPE: **Four- Month Option**
CREDITS: **4 hours per week. 6 CC. 4 EC**

Aims:

To complete student education in some aspects of Geotechnical Engineering which have not been dealt with in previous courses.

Teaching Organization:

Mainly theoretical lessons and also some practical ones devoted to the resolution of a set of exercises. Course work will be set as group work.

Bibliography:

- *"Geotecnia y Cimientos II y III", J.A. Jiménez Salas y otros, Editorial Rueda, Madrid, 1976 y 1980.*
- *"Rock Engineering", J.A. Franklin, M.B. Dusseault, Mc Graw Hill, 1989.*
- *"Rock Slope Engineering", E. Hoek, L. Bray, Institution of mining and metallurgy,London, 3rd ed. , 1981*
- *"Introduction to rock mechanics", R.E. Goodman, John Wiley, 2nd ed., 1989.*
- *"Underground excavations in rock", E. Hoek, E.T. Brown, Institution of mining and metallurgy, London, 1980, Versión en español por Mc Graw Hill, México, 1980.*
- *"Túneles: Planeamiento, diseño y construcción. (2 vols)", T.M. Megaw, J.V. Barlett, Ed. Limusa, México, traducido de la versión inglesa de Ellis Horwood (Wiley), New York, 1981*
- *"Dinámica de suelos y estructuras", R. Colindres, Limusa, 2 ed., México, 1993.*
- *"Finite elements in Geotechnical Engineering", D.J. Naylor, G.N. Pande, B. Simpson, R. Tabb, Pineridge Press, Swansea, 1981.*

Assessment:

Evaluation will be carried out on the basis of course work and a final exam.

Personal Tutorials:

A specific timetable will be posted.

Additional Information:

The course is considered as the last stage in the geotechnical education of the students. For this reason it is highly recommended to have previously read Geotechnical Engineering, which introduces knowledge that will be used later in Special Foundations.

Syllabus:

1. **INTRODUCTION TO ROCK MECHANICS**
   Rock mass features. RMR, RQD, Q indexes, geomechanics classifications. Initial stresses on rock masses, importance, "in situ" measures. Attributes of the matrix rock, basic aspects, mechanic behavior, laboratory techniques. Joints and its behavior inside a rock mass. Slope stability on rock, basic aspects.

2. **INTRODUCTION TO THE TUNNELS AND UNDERGROUND WORKS**
   Introduction, historic perspective. Typologies. Geomechanic classification adapted to tunnel excavation. Structures stability. Stress stability, stress analysis, support. Support design, characteristic tunnel curve. Hook and Brown breaking criterion. Constructive aspects, hoax. Basic aspects over tunnels, soil and urban area.

3. **INSTRUMENTAL WORK**
   Introduction, instruments on the geotechnical project. Motion and strain measure equipment, surveying, Strain gages, tiltmeters, micrometers, special equipment. Water pressure measure equipment, pressure gages, delay time. Stress measure equipment, total stress cells, initial stresses. Other special equipment: seismic instruments. Instruments for tunnel and underground works. Foundation instruments. Measurements in Dams.

4. **PROCESSING, IMPROVEMENT AND REINFORCEMENT OF THE GROUND**
   Introduction, necessity of processing. Pre-load, vertical drainage, control systems, compacting, basic aspects. Injections, mixes, gravel columns. Vibroflotation. Dynamic consolidation. Micropiles and bolts Geotextiles. Soil reinforcement methods. Reinforcing soil.

5. **STUDY OF SPECIAL FOUNDATIONS**
   Introduction. Towers and skyscrapers foundations. Bridges and piers foundations. Tanks foundations. Maritime foundations. Other cases that require special attention.

6. **EXPANSIVE AND COLLAPSIBLE SOIL FOUNDATIONS**
   Identification of expansive and collapsible soils. Expanding and collapsing mechanisms. Preventive measures. Corrective measures.

7. **FOUNDATION PATHOLOGIES. UNDERPROPS**
   Foundation construction outputs over adjacent structures. Subsidence phenomena: foundations in affected area. Underprops.

8. **SLOPES PATHOLOGIES**
   Instability analysis. Degradation and erosion of slopes. Landslides and fall of blocks.

9. **EXCAVATION DRAINAGE**
   Drainage typologies: excavations, dams, tunnels, mines. Pump diagrams: shafts, "well-point", electro-osmosis. Drainage in relation to the ground. Flow models, aproximations. Basic equations compilation, no stationary conditions. Two-dimensional flow, trenches. Flow with radial symmetry, isolated shafts, shafts system, charges leakage on shafts. Basic concepts of numerical methods to resolve the flow equation.

10. **INTRODUCTION TO SOIL DYNAMICS**
    Introduction. Stress-strain relations. Cushioning factor. Liquefaction and cyclic mobility. Laboratory trials. Simplified Seed Method to evaluate the liquefaction potential. Modern methods based on effective stresses. Machine foundations, basic concepts.

Control and Regulation of Traffic

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Ignacio Pérez Pérez**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To apply traffic science. To know and apply the methods of regulation of traffic.

Teaching Organization:

Theoretical lectures are taught and practical exercises related to the set topics are put forward.

Bibliography:

- *"Elementos de Ingeniería de Tráfico", Kraemer C., E.T.S. de Ingenieros de Caminos de Madrid.*
- *"Ingeniería de Tráfico". Antonio Valdés*
- *"Manual de Capacidad de Carreteras". Asociación técnica de carreteras. Comité español de la A.I. P. C.R.*
- *"Control de tránsito urbano". A. Martínez Márquez.*
- *"Modelos de tráfico vial". J. G. Gardeta Oliveros.*
- *"Traffic Engineering". William R. Macshane and Roger P. Roees.*
- *Magazines "CEDEX", Traffic Engineering and Control" and "Carreteras".*
- *Summaries of communications of different courses and monographic congresses.*

Assessment:

The assessment of the subject is carried out by means of a final exam. The participation in class and the handing in of the set practical exercises is taken into account.

Personal Tutorials:

Lecturers fix the timetable of personal tutorials weekly, in mutual agreement with the students.

Additional Information:

It is assumed that the students have a knowledge of traffic engineering and road design.

Syllabus:

1. THEORY OF ROAD TRAFFIC

Basic variables of traffic. Representation of traffic. Fundamental equation. Traffic models of deterministic type. Hydrodynamic or continuity theory. Analysis of shockwaves. Theory of tailbacks.

2. INTERSECTIONS WITH TRAFFIC LIGHT REGULATION

Movements and phases. Capacity and grade of saturation. Identification of critical movements. Intensity of saturation. Service levels. Calculation of cycle and distribution. Regulators. Detectors. Effects of the traffic lights on traffic. Location of traffic lights with respect to the road. Criteria of the installation of traffic lights.

3. TRAFFIC LIGHTS SYSTEMS

Coordination. Space- time diagrams. Proceedings for obtaining waves of progression with uniform velocity. Methods for improving progression. Situations of congestion. Flexible regulation in groups of intersections. Meshes with fixed- time traffic lights. Flexible regulation of traffic lights in an area. Centralized systems.

4. INTERSECTIONS WITHOUT TRAFFIC LIGHT REGULATION

Analysis of the capacity in intersection with two accesses regulated by stop signals and in intersections totally regulated by stop signals.

5. TRAFFIC CONTROL IN HIGHWAYS

Detection systems. Signaling and control systems. Safety systems. Control of bridges and tunnels. Control rooms. New technologies.

6. ROAD SAFETY

Importance of safety on the road. Factors which intervene in traffic accidents. Register of accidents. Study and analysis of accidents. Actions to improve safety in road traffic.

Structures III

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Luis Esteban Romera Rodríguez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To inform of the fundamental theories of the methods of discretization of structures in finite elements meshes. To know the problems of civil engineering to which these techniques apply. To know the types of finite elements most commonnly used. To learn to use programs of calculation of structures based on finite elements.

Teaching Organization:

For four hours per week theoretical lectures are given and basic exercises are resolved based on the theoretical explanations. Also in the laboratory of Calculation of Structures computer aided work is carried out on structural models to solve these problems by using finite elements programs.

Bibliography:

- *"Cálculo de estructuras por el método de elementos finitos", E. Oñate, CIMNE, 1992.*
- *"El método de los elementos finitos. Volumen 1. Formulación básica y problemas lineales", Zienkiewicz P.C., Taylor, R. L., McGraw- Hill, 1994.*
- *"The Finite Element Method. Linear Static and Dunamic Finite Element Analysis", J. J-R. Hughes, Prentice-Hall, 1987.*
- *"Finite element Procedures in Engineering Analysis", K.J. Bathe, Prentice- Hall, 1982.*
- *"Aplicación del método de los elementos finitos al análisis estructural de tableros de puentes", Samartín, Universidad de Cantabria, 1979.*
- *"Finite Element Programming", Hinton, E., Owen, D.R.J., Pineridge Press, 1980.*
- *" Análisis estático y dinámico de estructuras con el programa COSMOS/M", L.E. Romera; S. Hernández 1996.*

Assessment:

Final exams are held in February and September.

Personal Tutorials:

During working hours.

Additional Information:

It is assumed that the students have made used of matrix analysis programs.

Syllabus:

1. THE FINITE ELEMENT METHOD

Concept of discretization of a structure. Elements and joints of the structure. Concept of degree of freedom. Main types of elements. Nodal loads. Conditions of equilibrium and compatibility.

2. FINITE ELEMENTS IN TWO DIMENSIONAL ELASTICITY

Flat stress. Flat strain. Field of displacements, stresses and strains. Constitutive equations. Principle of virtual works. Triangular linear element. Discretizatin of the elastic problem. Nodal forces. Equations of equilibrium by means of VWP. Stiffness Matrix of the element. Stiffness Matrix of the structure. Calculation of the displacements, stresses and strains. Formulation of the previous problems by means of rectangular linear elements. Serendipitous rectangular elements. Langragian triangular elements of higher order. Elements of curved shape. Isoparametic elements.

3. INTEGRATION IN THE FINITE ELEMENT THE FORMULATION

Analytic integrals of triangular and rectangular elements with straight sides. Numerical integration. Quadrature of Gauss- Legendre. Comparative study of the most common elements.

4. TWO - DIMENSIONAL FINITE ELEMENTS

Solids of revolution. Definition of the model. Fields of displacements and strains. Field of stresses and constitutive equations. Triangular elements of three nodes: matrixes and associated vectors. Rectangular element of four nodes. Isoparametic elements.

5. THREE- DIMENSIONAL FINITE ELEMENTS

Definition of the model. Field of displacements, stresses and strains. Constitutive equations. Principle of virtual works. Linear tetrahedral elements. Lagrangian elements and serendipitous elements. Numerical three-dimensional integration. Three dimensional isoparametic elements. Comparative analysis between elements.

6. FINITE ELEMENTS IN THIN SLABS

Definition of the Kirchhoff model. Field of displacements, stresses and strains. Expression of VWP. Equations of equilibrium of the slabs. Rectangular plate elements; elements of four non - conforming nodes; elements of four conforming nodes. Triangular plate elements: triangular non - conforming elements and triangular conforming elements. Comparative analysis of elements.

7. FINITE ELEMENTS FOR THIN SHELLS

Kirchhoff shell model. Definition of the model. Field of displacements, stresses and strains. Equations of VWP. Selection of Kirchhoff flat shell elements. Problems of co-planarity. Problems of non-conformity. Elements of lowered flat shells. Curved elements.

8. STUDY OF THE ERROR IN FINITE ELEMENTS MESHES

Concept of error of a finite element. Estimations of error. Parameter of global error of the mesh. Parameter of refinement of the element. Criteria of optimum mesh: iso- distribution of the specific error.

9. ADAPTABLE MESHES IN FINITE ELEMENT MODELS

Redefinition of meshes methods. 'r' Method of relocation of joints. 'h' Method of increment of elements. 'h' Method of increment of the order of the elements. Combined methods.

Railways

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Miguel Rodríguez Bugarín**
OTHER LECTURERS:	**Alfonso Orro Arcay**
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

To identify the essential features of railway transportation, differentiating them from those in other transportation systems. To identify the track structure; to calculate its geometry and mechanical behaviour; to know and to identify the construction methods, diagnosis and maintenance of the track.

Teaching Organization:

During 4 hours a week, theory lectures are imparted and numerical examples are solved. Technical visits are organised to visit railway installations in the region, and maintenance and renovation works of tracks.

Bibliography:

- *"Ferrocarriles", García Díaz-de-Villegas, J.M. Publicaciones de la E.T.S. Ingenieros de Caminos, Santander, 2000.*
- *"La Vía del Ferrocarril", Alias, J. y Valdés, A. Editorial Bellisco, Madrid, 1990*
- *"Modern Railway Track", Esveld, C., MRT Productions, Duisburg, 1989.*
- *"Track geotechnology and substructure management", Seling, E. T. y Waters, J. M. Thomas Telford, Londres, 1994*

Assessment:

A final exam is carried out, with a theoretical part and another with practical questions. To pass the course it is required to pass both parts.

Personal Tutorials:

In working hours.

Additional Information:

Syllabus:

I. INTRODUCTION

1. **Transport Railways**

II TRACK STRUCTURE

2. **General considerations about the track**
3. **The rail**
4. **Rail junctions. Welded track**
5. **Turnouts**
6. **Sleepers. Rail fastenings and other track material**
7. **Ballast and substructure**
8. **Slab track**
9. **Brickworks**

III TRACK GEOMETRY AND MECHANICS

10. **Track geometry I**
11. **Track geometry II**
12. **Track mechanics. Vertical loads**
13. **Track mechanics. Track stability and longitudinal forces**
14. **Track quality deterioration**

IV TRACK WORKS

15. **Track inspection**
16. **Correcting track alignment**
17. **Track maintenance and renewal**
18. **Planning and construction of new railway lines**

Technical French

DEPARTMENT:	**Galician- Portuguese, French and Linguistics**
LECTURER IN CHARGE:	**Mercedes Regueiro Diehl**
OTHER LECTURERS:	
YEAR:	**2nd**
TYPE:	**Annual Option**
CREDITS:	**2 hours per week. 6 CC. 4 EC**

Aims:

To facilitate the beginners and "false beginners" in a rapid mastering and efficiency of basic competence in the French language, which will allow them to move easily in common communicative contexts: participate in simple conversations, to understand and be able to use real documents, to write basic texts, deal with professional and semiprofessional everyday situations.

Teaching Organization:

All lecture hours are of an eminently practical character. The involvement and active participation of the students in all the set activities is essential.

Bibliography:

- *"Le français à grande vitesse", Truscott S., Mitchell M.,Tauzin B., Hachette, París, 1994.*
- *"Grammaire. 350 exercises. Niveau dèbutant", Bady J., Greaves I., Petetin A. Hachette, París, 1996.*
- *"La nouvelle Bescherelle. L'art de conjuguer", Hattier, París, 1994.*
- *"Grammaire progressive du français", Grégoire M., Thiévenaz O., CLE Intern., París, 1995.*
- *"Vocabulaire illustré. 350 exercises. Niveau débutant", Filpa Ekwall D., Prouillac F., Wateyn Jones P., Hachette, París, 1992.*

Assessment:

Along the course there will be 2 written tests of partial assessment and one oral test. To pass 'by course' it is required to obtain a minimum mark of 5 out of ten in each one. Active participation of the students will be taken into account, not only in lectures but outside them (individual or collective projects).

Personal Tutorials:

The timetable of the tutorials will be posted at the beginning of the course.

Additional Information:

Syllabus:

1. LINGUISTIC OBJECTIVES

To introduce oneself. Greetings. Speaking in a personal situation. Quantification. Temporal localization. Journeys. Transport. Food and drink. Accommodation. Banks. Health. Clothes. Shopping. Leisure time. Characterization. Qualifying.

2. GRAMMATICAL CONTENTS

The noun: gender and number. The qualifying adjective: gender and number. The article: definite and indefinite, contract, partitive. The possessives, adjectives and pronouns: other structures to express possession. The demonstratives: determiners and pronouns; special uses of the demonstratives. The numbers. Personal pronouns. Negation. Interrogation: adjectives, pronouns and interrogative adverbs. The verb: the conjugations; the auxiliaries. The prepositions: principal prepositions. The adverbs: principal adverbs. Relative pronouns.

3. GROUP B

The students who already possess some previous knowledge of the French language are integrated in Group B practical lectures (intermediate level) and the objectives proposed are to maintain and update their linguistic skills of general French as well as familiarize them with the lexical and basic technical discourses. The classes of this group are focused on the multiple exploitation of technical documents of the most diverse origins, insisting fundamentally on reading comprehension, understanding that this is the skill which allows extracting information from specialised texts. Besides trying to master the minimum vocabulary of the different ambits of technique and technology, revising those morphological questions and syntaxes of greater scientific-technical occurrence and which present greater difficulty for Spanish speakers or Gallego speakers.

Reinforced and Prestressed Concrete II

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Fernando Martínez Abella, Cristina Vázquez Herrero**
OTHER LECTURERS:	**Manuel F. Herrador Barrios**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

To deepen the basic knowledge acquired in the subject Reinforced and Prestressed Concrete I, specially in the topics related with design and prestressed concrete.

Teaching Organization:

Theoretical and practical lectures are complemented with visits to different construction sites, laboratory practices, and lectures imparted by specialists.

Bibliography:

- *"Hormigón Armado y Pretensado II", Murcia, J., Aguado, A. y Marí, A.R., Edicions UPC, Barcelona, 1993.*
- *"Hormigón Armado". 14ª Edición basada en la EHE, ajustada al Código Modelo y al Eurocódigo. Jiménez, P., García, A. y Morán, F., Gustavo Gili, Barcelona, 2000.*
- *"EHE Instrucción de Hormigón Estructural", Ministerio de Fomento, Madrid, 1999.*
- *"Hormigón armado y pretensado. Ejercicios", Marí, A.R., Aguado, A., Agulló, L., Martínez, F., Cobo, D., Edicions UPC, Colección Politext, Barcelona, 1999.*
- *"Proyecto y cálculo de estructuras de hormigón ", Tomos I y II, Calavera,J., Intemac, Madrid, 1999.*
- • *"La EHE explicada por sus autores". Coordinador de la obra: Garrido, A., Leynfor, Madrid, 1999.*
- *"Estructuras de Hormigón Armado", Tomos I a VI, Leonhardt, F., El Ateneo, Buenos Aires, 1984.*
- *"Estructuras de Concreto Reforzado", Park, R., Paulay, T., Limusa, México, 1980.*
- *"Manual de Aplicación de la EHE. Materiales-ejecución-control (Comentado)", Garrido, A., Leynfor, Madrid, 1999.*
- *"Modern prestressed concrete: design principles and construction methods", van Nostrand Reinhold, New York, 1990.*
- *"PCI design handbook: precast and prestressed concrete", PCI, Chicago, 1999.*
- *Otros textos específicos a los que se hace referencia al inicio de cada tema.*

Assessment:

Evaluation consists of a Project of a prestressed or reinforced concrete structure. Possible holding of a teaching seminar on a theme to be determined.

Personal Tutorials:

They will be posted at the beginning of the course.

Additional Information:

To take this course, the student must have studied the subject Reinforced and Prestressed Concrete I

Syllabus:

1. **DESIGN OF REINFORCED AND PRESTRESSED CONCRETE STRUCTURES**
   1.1 Design basis: statically indeterminate concrete structures, Structural effects of deferred concrete strains, structural analysis, non-linear analysis: geometric non linearity and mechanical non-linearity. Strut-and-tie models. **1.2. Limit states**: ultimate limit state- anchorage, Ultimate Limit State of fatigue, service limit states: cracking of partially prestressed elements. Service limit State-vibrations, Ultimate Limit State Shear, Ultimate Limit State-Punching shear**. 1.3. Design criteria**: det ailing, advanced prestressed concrete technology, linear elements design, seismic resistant structures design, durability of structures, aesthetics.

2. **STRUCTURAL ELEMENTS**
   Prestressed concrete ties, deep beams, anchorage-blocks subjected to concentrated loads, supports, joints, short cantilevers, plates, shells, foundations, singular piers, prestressed concrete elements with post-tensioned unbonded tendons.

3. **PRESTRESSING TECHNOLOGY**
   Criteria in the selection of the prestressing systems. Initial steps in prestres sing (transport, sheaths, etc.), sheath grounting, stressing, maintenance and control.

Environmental Impact of Engineering Works

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Joaquín Suárez López**
OTHER LECTURERS:	**Alfredo Jácome Burgos and Estrella Rodríguez Justo**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know and understand the functioning of ecosystems, and the environmental factors with the aim of making an inventory of the environment. To study methodologies of evaluation of impacts and its application to studies and evaluations of environmental impact.

Teaching Organization:

For four hours a week lectures in theory are given. The student carries out a course project and different activities of exposition of topics.

Bibliography:

- *"Guía para la elaboración de estudios del medio físico: contenido y metodología", CEOTMA, Ministerio De Obras Públicas, Transporte y Medio Ambiente, MOPTMA, Madrid, 1992 .*
- *" Guía metodológica para la evaluación del impacto ambiental", Conesa Fdez., V., Mundi Prensa, Madrid, 1995.*
- *"Evaluación del impacto ambiental", Gómez Orea, D., Editorial Agrícola Española, S.A., 1994*
- *" Ecología para ingenieros. El impacto ambiental.", Hernández Fdez., S, Colegio de Ingenieros de Caminos, A-Z Ediciones y Publicaciones; 1987..*
- *"Guías metodológicas para la elaboración de estudios de impacto ambiental:... diversos títulos"., Monografías de la Secretaría de Estado para las Políticas del Agua y el Medio Ambiente, MOPT, 1989-1994*
- *"Ecología y formación ambiental", Vázquez, G., McGraw- Hill, Méjico, 1993..*

Assessment:

To pass it is necessary to have submitted the course project. Additionally, two final theory exams are held in February and September.

Personal Tutorials:

During working hours (with prior appointment with the lecturers) .

Additional Information:

It is important to have knowledge of Environmental Engineering. Orientated towards the students of the fifth course.

Syllabus:

1. INTRODUCTION
The environment. Environmental crisis. Environmental problems.

2. INSTRUMENTS OF ENVIRONMENTAL MANAGEMENT
Project and surrounding area. Preventative approaches. Corrective instruments. Producer and consumer agents. Planning.

3. ENVIRONMENTAL IMPACT
Definitions. Structuring and proceedings.

4. LEGAL FRAMEWORK
Introduction. European Union. National Legislation. Autonomous Communities.

5. PROCESS OF EVALUATION OF ENVIRONMENTAL IMPACT
Definitions and properties. Administrative approximation. Technical approximation. Proceedings.

6. CONTENTS OF THE STUDIES OF ENVIRONMENTAL IMPACT
Contents. Range and program. Types of EI according to its range, contents and program.

7. ENVIRONMENTAL INVENTORY
Abiotic factors. Biotic factors. Energy in the ecosystems. Ecological cycles. Ecosystems.

8. EVALUATION OF IMPACTS.
Identification of impacts. The environment or area affected. Characterization of the effects. Quantitative evaluations. Qualitative evaluations. Models of evaluation.

9. METHODOLOGIES
Problems. General methodologies.

10. PROGRAMMES OF VIGILANCE AND CONTROL

11. APPLICATION OF METHODOLOGIES
Hydraulic works. Linear works. Localized works.

12. GENERATION OF METHODOLOGIES

13. INSTRUMENTS OF ENVIRONMENTAL MANAGEMENT
Normalized methods of environmental management. ISO 14001. Audit techniques and final regulation. Legislation.

14. MANAGEMENT OF RESIDUES IN CIVIL ENGINEERING.
Classification of residues. Management techniques and final regulation. Legislation.

Maritime Engineering

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Gregorio Iglesias Rodríguez**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC**

Aims:

To fully endow the student with an ability for performing professionally in the field of ports and coasts, by means of knowing and developing studies and real projects. In short, to form specialist professionals in this field.

Teaching Organization:

For 4 hours per week lectures in theory are given, examples are given and resolved by means of the "case method" counting on the participation of the student. The carrying out of a study or a technical project is proposed with the category of coursework.

Bibliography:

- *"Recomendaciones para Obras Marítimas. ROM", MOTP, Programa ROM*
- *"Handbook of Coastal and Ocean Engineering", Herbich J.B., Gulf Publishing Co, 1991..*
- *"Nearshore Dynamics and Coastal Processes. Theory, Measurement, and Predictive Models", Horikawa K., U. Tokyo Press, 1998..*
- *"Coastal Engineering", Silvester R., Elsevier Scientific Pub. Co., 1974..*
- *"The applied dynamics of ocean surface waves", Mei C. C., John Wiley & Sons, 1983..*
- *"Plan director de infraestructuras 1993-2007", MOPT., S.G. Planificación y Concertaci.*

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Assessment:

It is necessary to carry out the exercises proposed during the course. At the end of the course a project or a previously accepted study of maritime engineering will be handed in. The analysis, planning, development and presentation of an adequate solution will be needed in order to pass; the obtaining of alternative solutions and/or original solutions will increase the mark. In these qualification marks, furthermore, the solutions given to the exercises submitted will be taken into account.

Personal Tutorials:

During working hours. In the exam period a specific timetable will be posted.

Additional Information:

It is assumed that the students have studied Harbours and Coasts. For the type of teaching method used, the programme of the subject can vary in accordance with the specific projects analysed by means of the method of "case study".

Syllabus:

1. **INTRODUCTION TO MARITIME ENGINEERING**

2. **ACTIONS AND RECOMMENDATIONS TO CONSIDER IN THE PROJECTS OF MARITIME ENGINEERING**
   Environmental. Construction. Service. Metoceanics: Waves, Wind, Currents, Variations in Sea- Level. Geotechnics.

3. **FIELD OF PORTS**
   Port projects: Safe harbours, water surfaces and maritime accesses; conditions of agitation, renovation of water, etc. Interior lineal works of loading and unloading; anchoring points, infrastructures, etc. Projects of readaptation and/or integral distribution of the port area. Plans for use of space, special plans for distribution, strategic plans. Constructive projects. Economic studies and of reliability. Project of specialised ports. Fishing, sports activities, industrial activities.

4. **FIELD OF COASTS**
   Projects for distribution of the shore. Regeneration of coastal physiographic units. Protection of the shore. Recuperation of shoreline spaces of environmental interest. Creation, amplification and protection of beaches. Works for coastal defence. Projects for rehabilitation of the sea- front of cities. Urban distribution, constructing sea promenades. Projects of road infrastructure on the shoreline. Conditioning of the physical surroundings, public domain, accesses to the sea, urban uses, industrial uses, etc. Special plans of distribution of *rias* and estuaries.

5. **FIELD OF STUDIES OF IMPACT ON THE ENVIRONMENT**
   Project of cleaning up coastal areas with waste spillage to sea. Special undersea outlets. Studies of environmental impact and/or contamination due to the ports (its traffic and operations), works and maritime structures (construction and useful life), other uses of the shore.

6. **FIELD OF STUDY OF PHYSICAL ENVIRONMENT**
   Projects and/ or studies of the hydrodynamics of ports, *rias* and estuaries. Maritime climate. Metoceanic actions on works, structures, floats and coastline. Environmental regimes and extremals Batimetric, geotechnic, etc. Projects of study of short- term and long- term evolution of the profile and ground of the coastline, especially the beaches.

7. **SPECIAL PROJECTS**
   Projects of development and/or execution of physical models of ports. Conditions of navigation and berthing, resistance of the exterior works, interior agitation, renovation of water, contamination, etc.-Physical models of dispersion, buttes, transport and degradation of the contamination. Interaction of works and maritime structures with the shore dynamic and its effect on the line and profile of the coast, etc. Execution and/or setting up computerised models of the problems raised. Especially about the behaviour of the shore dynamic and contamination in coastal waters, bays and rivers, etc. Special projects: Offshore structures, taking advantage of wind energy in coastal areas, taking advantage of the tides. Projects of aquaculture, etc.

Nuclear Engineering

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Javier Samper Calvete**
OTHER LECTURERS:	**Luis Montenegro Pérez**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

1. To provide a general view about Nuclear Energy oriented towards the needs of a civil engineer. 2. To provide the basic knowledge about nuclear physics, nuclear reactors and nuclear power plants. 3 To put emphasis in the design, construction, performance, dismantling and decommissioning of nuclear power plants and other nuclear facilities. 4. To compare the costs and environmental effects of nuclear energy with other sources of energy. 5. To provide information on radioactive waste management.

Teaching Organization:

The course is taught in the second semester with 4 hours per week of classroom lectures in 2 days. Invited lectures are also scheduled. In addition, technical visits to a nuclear power plant, and nuclear facilities such as El Cabril Power Station for low and intermediate level radioactive waste, uranium mines and the old uranium plant of Andujar (Jaén) are also envisaged.

Bibliography:

- *"Nuclear Reactor Engineering: Reactor Design Basics", S. Glasstone, A. Sesonske (Editor), Chapman & Hall, ISBN: 0412985217*
- *"Ingeniería de Reactores Nucleares", S. Glasstone, A. Sesonske, Editorial Reverté, ISBN: 8429140352*
- *"Radiochemistry and Nuclear Chemistry", G.R.. Choppin, J.O. Liljenzin, J. Rydberg, Butterworth-Heinemann, 1995, ISBN: 0750623004*
- *"Nuclear Chemistry" O. Navrátil, J. Hála, R. Kopunec, F. Macášek, V. Mikulaj, L. Lešetický, Prentice Hall, 1992, ISBN: 0136269044*
- *"Understanding Radioactive Waste", R.L. Murray, J.A. Powell (Editor), Battelle Press, 1994, ISBN: 0935470794*
- *"Radioactive Waste Management", Y.S. Tang, J.H. Saling, Hemisphere Publishig Corporation, 1990*
- *"Quinto Plan General de Residuos Radiactivos", Ministerio de Industria y Energía, 1999. (It could be obtained directly in ENRESA web page: www.enresa.es)*

Assessment:

The course grade is a weighted average of the grades obtained for attendance and participation in classroom lectures, conferences, technical visits, and a final course homework.

Personal Tutorials:

Each lecturer has their own weekly schedule of tutorials which is announced at the beginning of the academic year.

Additional Information:

Syllabus:

THEME 1. NUCLEAR PHYSICS

1.1. Basic concepts and structure of the matter
1.2. Ionizing radiations
1.3. Radiation-matter interactions
1.4. Doses and exposure
1.5. Nuclear reactions

THEME 2. NUCLEAR POWER PLANTS

2.1. Introduction
2.2. Theory of Nuclear reactors
2.3. Reactor refrigeration system
2.4. Reactor internal structure
2.5. Civil engineering of nuclear power plants
2.6. Maintenance and control during nuclear power plant operation
2.7. Dismantling and decommissioning of a nuclear power plant
2.8. Nuclear power plants in Spain

THEME 3. NUCLEAR FUEL CYCLE AND NUCLEAR SAFETY

3.1. Nuclear fuel cycle
3.2. Nuclear safety
3.3. Risks and nuclear accidents

THEME 4. NUCLEAR ENERGY

4.1. Introduction
4.2. Nuclear energy
4.3. Cost analyses

THEME 5. NUCLEAR WASTE

5.1. Introduction
5.2. Low and intermediate-level waste management
5.3. Dismantling of radioactive facilities
5.4. Policies for spent nuclear fuel and high-level waste management

THEME 6. APPLICATIONS OF RADIOACTIVE ISOTOPES IN CIVIL ENGINEERING

6.1. Applications of radioactive isotopes in civil engineering

Harbour Engineering

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Gregorio Iglesias Rodríguez**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

Specialised knowledge in the fields of planning, study, projects and building of ports and maritime works. The port and its surrounding area. Relationships between the port and the city. Means of communication.

Teaching Organisation:

Theoretical lectures are taught for 4 hours a week and examples are set and solved with the aim of trying to achieve the students' participation. The resolution of practical problems is set with the category of course work.

Bibliography:

- *"Curso de Ingeniería de Puertos y Costas", Rafael del Moral, José M AA Berenguer. Ed. Centro de Estudios y Experimentación de Puertos y Costas 1989.*
- *"Design of Marine Facilities", show IV Gaythwaite . Ed. Van Nostrand Reinhold (New York)*
- *"Port Design", Guidelines and Recommendations. Ed. Tapir Publishers (Norway)*
- *"Port Engineering", Peer Brauun.*
- *"Design and Construction of Ports and Marine Structures", A, Quinn. Ed. Mac Graw Hill(New York).*
- *"Travaux Maritimes", - 2 volumes. Jean Chapon. Ed. Eyrolles (Paris).*

Assessment:

It is necessary to do the exercises set during the course. The final exams will be held in June and September. In the final marks the adequacy and originality of the solutions given to the examples set during the academic year and the practical exercises handed in are taken into account.

Personal Tutorials:

In working hours. A specific timetable is posted in the exam period.

Additional Information:

Due to the objectives and content of this subject, it is assumed that the students have studied Harbours and Coasts.

Syllabus:

1. **INTRODUCTION**
   Basic concepts. Function of ports. Spanish port system.

2. **VESSELS, CHARACTERISTICS AND DIMENSIONS**
   Definitions. Dimensions, weights and capacities. Ship movements. Evolution and tendencies of the world fleet.

3. **GENERAL CONSIDERATIONS IN THE DESIGN OF PORT WORKS**
   Factors to consider in the design. Conditions and selection of the location. General criteria for the ground design . Actions in harbour works . R.O. M. 92

4. **DESIGN OF THE MARITIME AREA**
   Entrance canal. Horizontal alignment and transversal sections. Horizontal alignment of the shelter works. Dykes: types, areas of manoeuvre and anchoring. Docks.

5. **DESIGN OF DYKES**
   Mound breakwater: Analysis of the section type, Methods of Calculation, Parts of the cross section. Aspects and plan of construction. Vertical dykes. Mixed dykes.

6. **WORKS FOR BERTHING**
   Concept and function of the works for berthing. Quays. The construction process. Methods and equipment used. Criteria of design and of calculation. '*Duques de Alba*'

7. **DEFENCE AND MOORING EQUIPMENT**
   Berth manoeuvres. Types of defences. Criteria for their choice. Design of the defence system. Laying-up of vessels. Actions to consider.

8. **DREDGING**
   Concepts and classification. Evolution of the technology. Dredgers. Criteria to follow in the dredging plan. Environmental aspects.

9. **GEOTECHNICS IN MARITIME WORKS**
   Reconnaissance of the ground. Characteristics of the ground. Foundations. Slopes. Quays and fillings. Piles. Camp sheathing areas. Method for improving the land.

10. **NAVIGATION AIDS**
    Role of navigation aids. Types used. Management systems and planning of maritime traffic (VTS).

11. **PLANNING THE LAND AREA OF THE PORT**
    Land accesses. Road and railway. Installation of the quays. Storage and containers.

12. **FISHING PORTS**
    Concept and classification. The fishing fleet. Functions of the fishing port. Design. Fish market and installations of commercialisation.
13. **MARINAS**
    Concept and classification. Sports vessels. Planning phases. Harbour and mooring. Auxiliary installations.
14. **CONSTRUCTION. RESTORATION. MAINTENANCE AND REPAIR OF PORT WORKS.**
15. **THE PORT AND ITS SURROUNDING AREA. RESTORATION OF OLD PORT WORKS FOR URBAN USES.**

Geotechnical Engineering III

DEPARTMENT:	**Constructi on Technology**
LECTURER IN CHARGE:	**Luis Medina Rodríguez**
OTHER LECTURERS:	**Manuel Melis Maynar and Jorge Molinero**
YEAR:	**4th**
TYPE:	**Four- month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

The main aim of this subject is to supply the students with the necessary knowledge and information about Foundation Engineering: Subsoil exploration, shallow and deep foundation design, and the design of earth retaining structures.

Teaching Organization:

Theoretical lectures and the resolution of practical problems. Some practices with commercial finite element codes. During the course students carry out visits to construction works. In order to improve their qualifications, groups of students may voluntarily carry out works about specific points concerning the subject.

Bibliography:

- *"Geotecnia y Cimientos II y III", J.A. Jiménez Salas y otros, Editorial Rueda, Madrid, 1976 y 1980.*
- *"Curso aplicado de cimentaciones", J.M. Rodríguez Ortiz, J. Serra Gesta, C. Oteo Mazo, Colegio Arquitectos de Madrid, 6 edición, 1995*
- *"Pile foundation analysis and design", H.G. Poulos, E.H. Davis, John Wiley \& Sons, New York, 1980.*
- *"Foundation Analysis and Design", Joseph E. Bowles. Mc. Graw-Hill*
- *"Diseño y construcción de cimientos", M. J. Tomlinson. Urmo, S. A. de ediciones.*
- *"Mecánica de suelos en la ingeniería práctica", K. Terzaghi y R. B. Peck. Editorial El Ateneo.*
- *"ROM 0.5-94", MOPTMA.*
- *"Cours de mécanique des sols", Enseignement T6-T9. Foundations et soutènements. Ècole Nationale des Ponts et Chaussées.*

Assessment:

Qualification will be obtained through the corresponding examination and the evaluation of the voluntary works.

Personal Tutorials:

Six hours per week. The timetable is posted on the student notice board.

Additional Information:

Before enroling for this subject it is highly recommended to have passed *Geology and Introduction to Geotechnical Engineering* and *Geotechnical Engineering II.*

Syllabus:

1. SUBSOIL EXPLORATION

Planning for soil exploration. Exploration techniques. Boring methods. Rock coring. Sampling methods, disturbance. Piezometers. Permeability tests in the field: Lefranc, Lugeon and pumping tests. Cone Penetration Test: description and empirical correlations. Piezocone: description, corrections and empirical correlations. Standard Penetration Test: description, corrections and empirical correlations. Borros test. Vane shear test. Borehole pressure meter test: Menard's device and self-boring pressuremeters. Plate load test. Geophysical exploration: seismic and electrical methods. Georadar. In situ tests versus laboratory tests.

2. SHALLOW FOUNDATIONS

Typology of foundations. Design aspects. Bearing capacity expressions. Correction factors. Bearing capacity in special situations. Bearing capacity from field tests. Settlements under shallow foundations: oedometric and Skempton-Bjerrum methods, the elastic method, the stress path method, methods based in field tests (plate load test, SPT and CPT). Rotation of bases. Maximum settlement allowed. Interaction between foundations. Techniques for reduction of settlements. Safety factors. Analysis of soil-structure interaction: beam on elastic foundation, Winkler's model, modulus of subgrade reaction. Mat foundations: typology, design and construction aspects.

3. DEEP FOUNDATIONS

Typology. Methodology of design. Piles: classification and description. Single piles: static piles capacity, point capacity and skin capacity in sands and clays. Piles on gravel and rocks. Dynamic analysis: pile driving, Hiley's equation. Settlement of piles. Elastic method (Poulos). Instantaneous and non-instantaneous settlements (floating piles y columns). Laterally loaded piles: Winkler's model. Pile groups: typology, efficiency, bearing capacity in sands and clays, settlements. Negative skin friction in piles: Jiménez-Salas' method. Lateral loads due tosoil movements. Special situations.

4. EARTH RETAINING STRUCTURES

Typology. Rigid and flexible structures: concrete retaining walls, cantilever retaining walls, sheet pile walls, slurry walls. Wall stability. Wall drainage. Parallel walls. General methodology for the design of retaining walls. Technological aspects of wall construction. Sheet pile walls: pressure distribution, effect of water, cantilever sheet- piling, anchored sheet piling (free-earth support and fixed-earth support methods). Anchorages: basic concepts. Construction processes of slurry walls.

5. NUMERICAL METHODS IN GEOTECHNICAL ENGINEERING

Introduction. Basic concepts of the Finite Element and Finite Difference methods. Constitutive equations. Elastic and elasto- plastic models. Critical State models: Cam clay and modified Cam clay models. Boundary and initial conditions. Total and effective stresses. Construction processes. Fluid -soil interaction: couple and uncoupled problems, consolidation. Formulation of dynamic problems. Examples.

Technical English

DEPARTMENT:	**English Philology**
LECTURER IN CHARGE:	**Alberto Dopico García**
OTHER LECTURERS:	
YEAR:	**1st**
TYPE:	**Compulsory Annual**
CREDITS:	**2 hours per week. 6 CC. 4 EC**

Aims:

Students should be able to handle English vocabulary and structures relating to the fields of science, civil engineering and economics, as well as being able to formulate business correspondence and technical reports in English.

Teaching Organization:

Students will attend two hours of class per week, classes will concentrate on the four pillars of language learning: Comprehension; oral skills; translation and interpreting (English – Spanish / Spanish – English).

Bibliography:

- *"Nuevo diccionario politécnico de las lenguas española e inglesa", Beigbeder F., Ed. Díaz de Santos, S.A.*
- *"Technical English for Industry", Yates C.S.J., Fitzpatrick A. Ed. Longman..*
- *" Diccionario para Ingenieros", Robb L.A., CECSA*
- *"Diccionario de Arquitectura, Construcción y Obras Públicas", Putman y Carlson. Ed. Paraninfo, S.A.*
- *"International Business English" (Student book), Jones L., Alexander R., Cambridge University School.*
- *"Writing for Business", Wilson M., Ed. Nelson..*

Assessment:

Attendance at school and the completion of all set work is compulsory to pass the course; in addition, two final exams will be set, in June and September.

Personal Tutorials:

A timetable for tutorial hours will be made available at the beginning of each year.

Additional Information:

Syllabus:

1.- INTRODUCTION TO THE NUMERICAL LANGUAGE
2.- EVERYDAY LANGUAGE
3.- TECHNICAL VOCABULARY
4.- BUSINESS AND PROFESSIONAL CORRESPONDENCE
5.- MEMORANDA
6.- FACSIMILE
7.- TELEX
8.- BILLS OF PURCHASE
9.- INVOICING
10.- INTERNATIONAL METHODS OF PAYMENT
11.- INTERNATIONAL COMMERCE TERMS (INCOTERMS)
12.- APPLICATION FORMS
13.- CURRICULUM VITAE.
14.- THE ADVERTISEMENTS IN A DAILY PAPER
15.- TECHNICAL REPORTS
16.- COMPUTING
17.- MARKETING
18.- USE OF TELEPHONES
19.- PHONOLOGY
20.- CONTEXTUAL GRAMMAR AND SEMANTICS

Advanced Numerical Methods

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Fermín Navarrina Martínez**
OTHER LECTURERS:	**Ignasi Colominas Ezponda and Gonzalo Mosqueira Martínez**
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To study in depth the constructive methods which allow solving numerically the most frequent mathematical problems in Civil Engineering.

Teaching Organization:

The teaching activity is based four hours per week, on theoretical lessons and on solving the practical exercises which are previously set. In the facilities of the Centro de Cálculo, the students have to solve a series of application problems, so that they have to prepare several FORTRAN programs as course work.

Bibliography:

- *"Finite Elements and Approximations", Zienkiewicz, O.C. and Morgan, K., John Wiley \& Sons, New York, 1983*
- *"The Finite Element Method: Lineal Static and Dynamic Finite Element analysis", Hughes, T.J.R., Prentice-Hall, Englewood Cliffs, 1987*
- *"Numerical Solution of Partial Differential Equations by the Finite Element Method", Johnson, C., Cambridge University Press, Cambridge, 1987*
- *"Finite Elements Analysis and Applications", Wait, R. and Mitchell, A.R., John Wiley \& Sons, New York, 1985*
- *"Finite Elements: I) An Introduction, II) A Second Course, III) Computational Aspects, IV) Mathematical Aspects, V) Special Problems in Solid Mechanics, VI) Fluid Mechanics. \rm (Seis volúmenes)", Carey, G.F. and Oden, J.T., Prentice-Hall, Englewood Cliffs, 1986*
- *"Iterative Solution of Large Sparse Systems of Equations", Hackbusch, W., Springer -Verlag, New York,1994*

Assessment:

To pass the exam it is essential to have done the works during the course. Two final exams are held, one in June and another in September. In the final mark the marks of the works during the course and the practices done are taken into account.

Personal Tutorials:

During working hours, and also during the hours shown on the tutorial timetable posted on the notice board.

Additional Information:

It is advisable to follow this subject after doing Numerical Calculus.

Syllabus:

1. INTRODUCTION

Review of the fundamental concepts of continuum: Conservation and Constitutive Equations: Outline Conditions: examples in Civil Engineering and Mechanics. Review of the fundamental concepts of Finite Differences. Discreet Systems.

2. INTEGRAL FORMULATION

The Method of Weighted residuals: Approximation of a function and generalization of the concept of Spline; Approximation of a solution of a differential equation; Approximation of the solution of a differential equation with boundary conditions; Natural boundary conditions; Introduction to the Method of the boundary elements; Generalization to systems of differential equations. Virtual Works: General Formulation. Introduction to variational methods.

3. BASIC CONCEPTS OF MEF AND APPLICATIONS

Simple models of One-dimensional Finite Elements: Introduction. Assembly: Geometric Interpolation; Numerical integration; Organization of a computer program; Applications (transmission of heat, lineal elastic members piece under traction, one-dimensional seepage). Two and three dimensional Finite Elements: Shape functions: Isoparametric elements; Techniques of numerical integration; Applications (Poisson's equation, lineal elasticity). Introduction and basic methodology: Exact integration and modal decomposition: Equations of First Order (Single Step methods, Multiple Step methods, stability), Equations of Second Order.

4. INTERACTIVE METHODS FOR SYSTEMS OF LINEAL EQUATIONS

Introduction. Classification of available techniques: Criteria of inversibility: Notions of validity and precision: Generalities of iterative methods: Global description of iterative methods. Chebyshev's Acceleration. Conjugated Gradients. Jacobi's Method for elements and blocks. Gauss-Seidel Method for elements and blocks. Relaxation Method: Coefficient of optimum ratio; Coefficient of adaptive ratio; Application to the solution of differential equations. Comparative analysis of different methods.

5. SOLUTION OF NON-LINEAL SYSTEMS

Introduction: Origins of Non-Lineal problems: Linearisation of problems: Existence and uniqueness of solutions. Convergence. Elemental Methods: Successive Approximations and Fixed Point methods. Generalization of iterative methods. Newton-Raphson Method. Variants of Newton-Raphson Methods: Modified Newton-Raphson Methods: Simple Newton Method. Quasi-Newton Methods: Introduction and Classification: Broyden Method: DFP Direct Quasi-Newton Methods. BFGS Inverse Quasi-Newton Methods; Newton-Secant Methods. Other techniques for specific problems.

Dams

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Rodrigo del Hoyo Fernández Gago**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know the types of dams, project methods, construction and exploitation. To determine the actions to take into account to analyse its stability and tensional state. To determine the maximum flood. To know the systems of auscultation as well as the dimensions of the organs of outlet. To understand the influence of foundations in the behaviour of the dam.

Teaching Organization:

For four hours per week lectures in theory are given and previously set practices are resolved.

Bibliography:

- *"Tratado Básico de Presas", E. Vallarino. Colegio de Ingenieros de Caminos..*
- *"Advanced Dam Engineering", R.B Jansen. Van Nostrand Reinholds- N. York..*
- *"Handbook of Dam Engineering", A.R. Golze. Van Nostrand Reinholds - N.York*
- *"The Engineering of Large Dam", H.H. Thomas. John Wiley sons- N. York.*
- *"Design of Gravity Dam". U.S Bureau of Reclamation..*
- *"Design of Archs Dam". U.S. Bureau of Reclamation.*
- *" Arch Dam", Laginha Serafín. Balkena.*
- *" Earth and Earth Rock Dam", Sherard. John Wiley Sons - N. York.*
- *"Presas de Tierra y Enroscamiento", Marsal. Limusa*
- *"Geothechnical Engineering of Embankment Dams", Tell and others. Balkena.*
- *" Design of Small Dams". U.S. Bureau of Reclamation.*

Assessment:

In order to pass it is necessary to have done the course projects. Final exams are held in June and September.

Personal Tutorials:

During afternoons of the week days.

Additional Information:

Syllabus:

1. **INTRODUCTION TO THE STUDY OF DAMS**
   Reasons for building a Dam. Types of dams. Dams through history.

10. **LESSONS OF ACCIDENTS**
    Exposition of various dam accidents and lessons to be learnt.

3. **ACTIONS TO CONSIDER**
   Forces which act on the dam.

11. **STUDY OF FLOODS**
    Probabilistic and determinist methods. Flood of project and maximum flood. Recommendation to adopt regarding the flood.

12. **KNOWLEDGE OF THE DAM**
    Geological and geotechnical investigation. Determining the parameters of foundations. Localising materials.

13. **CONSTRUCTION OF DAMS AND ACTIVITIES COMMON TO ALL TYPES OF DAMS**
    Planning. Diversion of River. Excavation Treatment of the land.

14. **DAMS OF LOOSE MATERIALS**
    Homogenous dams and with nucleus. Filters and drains. Nucleus' and verges. Stability. Construction methods.

15. **ROCKFILL DAMS WITH RESERVOIR**
    Rockfill as construction material. Compaction. Dams with reservoir of traditional concrete.

16. **OTHER DAMS OF LOOSE MATERIAL**
    Reservoir dams with geomembranes. Dams with asphaltic nucleus.

17. **FACTORY DAMS. GRAVITY DAMS**
    Design. Stability. Tensional state. Construction methods of dams of traditional concrete.

18. **FACTORY DAMS. ARCH DAMS**
    Typology and evolution of arch dams. Design. Construction. Methods of calculation.

19. **DAMS OF CONCRETE COMPACTED WITH ROLLER**
    Specific problems of Project and Construction.

20. **SPILLWAYS**
    Typology. Hydraulic analysis. Dissipation of energy. Structures and Overflows.

21. **DEEP OUTLETS**
    Dimensioning. Valves and Overflows.

22. **VIGILANCE AND AUSCULTATION OF DAMS**
    Magnitudes which are measured. Teams of auscultation. Studies and Reports on the state of safety. Exploitation of dams in floods. Studies to be developed.

Bridges I

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Santiago Hernández Ibáñez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know the different typologies of straight bridges, their structural behaviour and the construction procedure employed. At the same time, to be able to distinguish the methods of calculation used in their analysis.

Teaching Organization:

For four hours a week lectures in theory are given and sessions of practical exercises are held. At the same time in the Laboratory of Computer Aided Calculation of Structures, models of bridge-decks and models of complete structures of bridges are designed to be resolved by means of Finite Elements programs.

Bibliography:

- *ARENAS, J.J. and APARICIO, A.C* Aparatos de apoyo para puentes y estructuras. *Servicio de Publicaciones, E.T.S.I.C.C.P., Santander.*
- *FERNÁNDEZ TROYANO, L.* Tierra sobre agua. Visión histórica universal de los puentes. *Colegio de I.C.C.P*
- *MANTEROLA, J.* Puentes I *E.T.S. Ingenieros de C.C. y P., Madrid.*
- *MANTEROLA, J.* Puentes II *E.T.S. Ingenieros de C.C y P., Madrid.*
- *SAMARTÍN, A.* Cálculo de estructuras de puentes de hormigón, *E. Rueda, Madrid.*.
- *O' BRIEN, E.* Bridge Deck Analysis. *Chapman and Hall.*.

Assessment:

In order to pass the exam it is necessary to do the set course projects. Two final exams will be held in June and in September.

Personal Tutorials:

During working hours.

Additional Information:

It is assumed that the students know the computer programs of calculation of structures by the Finite Element Method.

Syllabus:

1. **INTRODUCTION**
   General definitions. Classification of bridges. Historic evolution of typologies. Natural facts and conditioning factors. Actual morphologies and construction processes.

2. **DESIGN LOADS AND REGULATIONS**
   Documents and regulations for the project of bridges. Regulation of road bridges and railway bridges. Definition of actions. Regulations of road and railway bridges. New regulation IAP-96.

3. **SLAB DECKS**
   General description. Longitudinal morphology. Transversal section. Resistant behaviour. Construction processes. Construction span by span.

4. **CALCULATION OF DECKS. GRILLAGE METHODS**
   Matrix analysis of flat grillages. Definition of model. Obtaining of the characteristics. Application of loads. Analysis of results. Wood and Armer's method.

5. **CALCULATION OF DECKS: FINITE ELEMENTS**
   Finite elements in slabs. Flexion Finite Elements. Modelization of bridge decks. Interpretation of the results.

6. **BEAM DECKS**
   General description of the morphology. Criteria of dimensioning. Process of calculation. Behaviour of beam decks. Disposition of tie beams. Membrane effect of the upper slab. Construction of beam decks.

7. **BOX SECTION BRIDGES**
   Morphology. Dimensioning. Resistant answer: Flexion, torsion, distortion. Calculation of decks with box sections. Decomposition in accordance with the resistant answer. Design and construction of box section bridges by successive cantilevers.

8. **SUBSTRUCTURE OF BRIDGES**
   Introduction. Morphology of columns. Construction of columns. Morphology of abutments. Concrete joints. Elastometric supports and neoprene- Teflon. Joints.

9. **CALCULATION OF SUBSTRUCTURE**
   Behaviour of supports and its dimensioning. Calculation of horizontal actions on piles and abutments. Lineal calculation of piles. Non- lineal calculation of piles. Dimensioning abutments.

10. **OBLIQUE AND CURVED- IN- PLAN BRIDGES**
    Methods of analysis of the deck. Influence of curvature. Construction aspects.

Bridges II

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Santiago Hernández Ibáñez**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To describe the advanced typology of metallic, concrete and mixed bridges. To know the behaviour of bridges in the aeroelastic phenomena.

Teaching Organization:

For four hours a week lectures in theory are given and sessions of practical exercises are held. At the same time in the Laboratory of Computer Aided Calculation of Structures, models of bridge-decks and models of complete structures of bridges are designed to be resolved by means of Finite Elements programs.

Bibliography:

- *Menn, C.* "Pretensed Concrete Bridge". *Springer- Verlag, Viena.*
- *Manterola, J.* "Puentes III". *E.T.S. Ingenieros de C.C. y P.,Madrid.*
- "Recomendaciones para el proyecto de puentes mixtos" *RPX-95. Ministerio de Fomento.*
- *Gimsing, N.J.* "Cable Supported Bridges". *John Wiley & sons Inc., New York.*
- *Simiu, E. & Scalan, R.H.* "Wind Effects on Structures. Fundamentals and Applications to Design". *John Wiley & sons, 1996.*
- *Rosignoli, M.,* "Launched Bridges", *ASCE Press.*

Assessment:

In order to pass the exam it is necessary to do the set course projects. Two final exams will be held in June and in September.

Personal Tutorials:

During working hours.

Additional Information:

It is assumed that the students know the computer programs of structure calculation by the Finite Element Method and have passed the subject *Bridges I.*

Syllabus:

1. **STRAIGHT BRIDGES WITH SPECIAL CHARACTERISTICS**
   Gate bridges: Historical development and implementation. Calculation and construction processes. Thrust bridges. Construction processes. Construction by successive cantilevers.

2. **METAL AND MIXED SECTION BRIDGES**
   Introduction. Regulations of application: RPX, RPM, EC-4. Analysis of decks, mixed double action, piles. Construction processes.

3. **ARCH BRIDGES**
   Historic development of the materials, implementations. Antifunicularity. The rigid arch and the laminar arch: Calculation. Construction processes.

4. **CABLE- STAYED BRIDGES**
   Historic development: Materials, implementations. Spar, decks, cables: Structural behaviour. Structural analysis and technology of trussing

5. **SUSPENSION BRIDGES**
   Historic development: Materials, implementations. Structural analysis. Constructive processes.

6. **DYNAMIC ACTIONS**
   Dynamic actions. Seismic actions. Wind actions. Experimental aeroelasticity. Computational aeroelasticity.

7. **THE LIMITS OF DESING : NEW TYPOLOGIES AND MATERIALS**
   State of art of design, typology and materials.

Urban Services

DEPARTMENT:	**Architectonic Projects and Urbanism**
LECTURER IN CHARGE:	**Carlos Nárdiz Ortiz**
OTHER LECTURERS:	**Juan Creus Andrade**
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To instruct the student in the urbanization projects of the urban road network and the public spaces of the city.

Teaching Organization:

The course has a theoretical component derived from the explanation of the program, and a practical component related to the composition of a project of the urbanization of a soil previously legislated for at a planning level, or of a free space of the badly urbanized city to recover it for public uses.

Bibliography:

- *"Recomendaciones para el proyecto y diseño del viario urbano". MOPTMA. Series Monográficas. Madrid 1995.*
- *"El Paisaje urbano. Tratado de Estética Urbanística". GORDON CULLEN. Ed. Blume. Barcelona, 1981.*
- *"Secciones Estructurales de Firmes Urbanos en Sectores de nueva Construcción". E. ALABERN Y C. GUILLEMANY, 1990..*
- *"Instalaciones Urbanas. Infraestructura y Planteamiento". L.J. ARIZMENDI. Ed. Bellisco. 1991- 1996..*
- *"Implantación y coordinación de los Servicios en la ejecución de las obras de urbanización". E. ALABERN and C. GUILLEMANY. 1990.*

Assessment:

The evaluation is based on practical exercises carried out throughout the course as a complement of the theoretical lectures and in the Project of Urbanization which is the main practical part of the course.

Personal Tutorials:

During working hours. A tutorial timetable is established for the correction of practical exercises.

Additional Information:

That derived from the public space which is intervened in and the use of cartography at different scales.

Syllabus:

1. **INTRODUCTION TO THE CONCEPT OF URBAN SERVICES AND THE PLANNING OF THE URBANIZATION.**
2. **THE URBAN ROAD NETWORK.**
3. **THE DEFINITION OF THE STREET IN GROUND PLAN AND ELEVATION.**
4. **THE DEFINITION OF THE STREET IN SECTION.**
5. **THE DEFINITION OF THE ROAD INTERSECTIONS.**
6. **THE TECHNIQUES OF PLANNING OUTDOOR SPACE.**
7. **THE PLANNING OF SQUARES, AVENUES AND URBAN FRINGES**
8. **THE STREET PAVEMENT**
9. **THE PEDESTRIAN AREAS PAVEMENT**
10. **COMPLEMENTARY URBAN ELEMENTS**
11. **DRAINS AND SEWAGE NETWORKS**
12. **ELECTRICAL AND LIGHTING NETWORKS**
13. **OTHER URBAN SERVICES AND THEIR COORDINATION**
14. **DRAWING UP THE PLANNING OF URBANIZATION**
15. **MANAGEMENT OF URBAN SERVICES**

Expert Systems

DEPARTMENT:	**Computation**
LECTURER IN CHARGE:	**Vicente Moret Bonillo**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know, comprehend and apply the constructive methods of non-deterministic programming. To know the basic aspects of the artificial intelligence and of the engineering of knowledge. Apply the concepts in interesting cases for civil engineering.

Teaching Organization:

The teaching activity is based on theoretical lessons during four hours per week where problems are solved. During the course, specific course works are proposed and also a specific topic which is to be conceptualized, formalized, elicited and operationalized in order to design and develop a small expert system in the field of civil engineering.

Bibliography:

- *"Principios de Inteligencia Artificial y Sistemas Expertos", D.W. Rolston, McGraw-Hill, eds., 1990*
- *"Inteligencia Artificial", E. Rich, Knight, Gustavo-Gili, eds., 1995*
- *"Principios de Inteligencia Artificial",Díaz de Santos, eds., 1987*
- *"A Guide to Experts Systems", Addison-Wesley, eds., 1986*
- *"IEEE Expert (Journal)", IEEE Press.*

Assessment:

To pass the course it is essential to attend the lessons. The assessment is based on a final exam. In order to pass the course the student has to obtain a minimum mark. In the final mark the quality of the works presented in the lectures is taken into account.

Personal Tutorials:

During working hours, and also during the hours shown on the tutorial timetable posted on the notice board.

Additional Information:

It is assumed that the student has basic notions in programming. It is recommended to have a basic knowledge in C language.

Syllabus:

1. INTRODUCTION AND GENERAL CONCEPTS

Historic development. Fundamental ideas. Definitions and Concepts. Conventional Programming vs. Artificial Intelligence.

2. RESOLUTION OF PROBLEMS IN ARTIFICIAL INTELLIGENCE

Space of States and Search for Solutions. Characteristics of the Processes of Search. Heuristic Search. Lesser Methods of Exploration of Space of States. Analysis of Algorithms of Search.

3. SCHEMES OF REPRESENTATION OF KNOWLEDGE

Formal schemes of representation of Knowledge. Declarative Methods of Representation. Procedural Methods. Rules and Systems of Production.

4. METHODS AND MODELS OF REASONING

Categorical Reasoning. Bayesianne Approximation. Model of the Factors of Certainty. Evidential Theory of Dempster and Shaffer. Diffuse Logics.

5. ENGINEERING OF KNOWLEDGE AND EXPERT SYSTEMS

Ideal architecture of an Expert System. Knowledge Bases: Organization of Static Knowledge and Dynamic Knowledge. Motor of Inferences. Interaction of Systems with the User and with the exterior. Ideal Methodology of Design. Acquisition of Knowledge. Verification and Validation of Expert Systems.

Urbanism II

DEPARTMENT:	**Architectonic Projects and Urbanism**
LECTURER IN CHARGE:	**Cándido López González**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month optional**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

Basic theoretical and practical knowledge necessary for the elaboration, evaluation and carrying out of the Planning. The subject is structured in three parts: A. URBAN INFORMATION, B. THE ELABORATION OF THE PLANNING AND C. THE EXECUTION AND MANAGEMENT OF THE PLANNING detailed in the enclosed program.

Teaching Organization:

Theoretical and practical lectures will be taught for four hours a week. The students will analyze real set tasks and will carry out the main contents of some planning figures.

Bibliography:

- *"Elementos de Ordenación Urbana", Juli Esteban i Noguera, Colegio de Arquitectos de Cataluña. Barcelona, 1981.*
- *"Introducción al Planteamiento Urbano", Juan A. Santamera, Colegio de Ingenieros de C.C y P. Madrid, 1996.*
- *"Texto Refundido de la Ley sobre el Régimen del Suelo y Ordenación Urbana y sus Reglamentos", varios: B.O.E, Tecnos, Civitas,....*
- *"Lei do Solo de Galicia", varios: D.O.G.A, Xunta de Galicia,....*
- *"Directrices para a Ordenación Urbanística dos Municipios Galegos", Consellería de Ordenación do Territorio e Obras Públicas, Xunta de Galicia, 1992.*

Assessment:

Continuos assessment, by means of following the course work and explanations of the students.

Personal Tutorials:

They will be fixed by mutual agreement with the students.

Additional Information:

Syllabus:

A1. ELEMENTS OF TERRITORIAL ORGANIC STRUCTURE

A2. ASSESSMENT OF LAND: USES AND APTITUDES

A3. THE INTERPRETATION OF URBANISTIC INFORMATION.

B1. PRACTICE OF URBANISM: OBJECTIVES, INTERESTS AND CONFLICTS.

B2. LEGAL FRAMEWORK. PREVIOUS ACTS AND JURISDICTION.

B3. INSTRUMENTS OF PLANNING AND GENERAL CLASSIFICATION OF LAND

B4. DEMARCATION AND QUALIFICATION OF LAND: ZONES AND SYSTEMS

B5. REGULATION OF ACTIONS: URBAN LAWS AND ORDENANCES OF BUILDING

B6. PROTECTION OF THE HERITAGE AND THE ENVIRONMENT

B7. SUMMARY OF THAT WHICH WAS GIVEN PREVIOUSLY AND ASSESSMENT OF THE PLANNING PROPOSALS.

C1. PROGRAMMING OF ACTIONS AND ECONOMIC STUDY

C2. CONTROL OF PLANNING AND URBAN DISCIPLINE.

Management and Operation of Harbours

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Juan R. Acinas García**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- month Option**
CREDITS:	**4 hours per week. 6 CC. 4 CC**

Aims:

Specialised knowledge in the areas of transport, scheduling, management and operation of harbours. Users, goods, operations. Economic and administrative structure of harbours.

Teaching Organization:

During four hours a week lectures will be made up of theory, and outline and solve examples in order to achieve the participation of the student. Different applications will be proposed which will constitute the course work

Bibliography:

- *"Análisis económico del sistema portuario gallego", GONZÁLEZ LAXE, F., et al, 1999. Instituto de Estudios Económicos. Fundación Barrié de la Maza.*
- *"Dirección y explotación de puertos", RODRIGUEZ F.,1985. P. A . Bilbao.*
- *"Libro Verde sobre los Puertos y las Infraestrcturas Marítimas", UE. CCE, 1997. Comisión de las Comunidades Europeas. Bruselas 10/12/1997.*
- *"Los puertos de Europa. Guía de la organización de puertos europeos", ESPO, 1998.*
- *"Memorias de actividades. Anuarios estadísticos. Boletines de Información mensual, ..", Fomento, Ente Público Puertos del Estado.*
- *"Modelo europeo de excelencia empresarial para el sector público. Autoridad portuaria: Caso práctico", FUNDACIÓN PORTUARIA, 1999. European Foundation for Quality Management EFQM.*
- *"The business of shipping", KENDALL, L. C. & BUCKLEY, J. J., 1994. 6th ed. Cornell Maritime Press.*
- *"Transportes Marítimos de Línea Regular", BLANCO, A., 1997. A. P. Valencia.*
- *"Dirección y explotación de puertos", Rodríguez F., P. A. Bilbao, 1985.*

Assessment:

It is necessary to do the course work. There will be an exam in July and another in September. The aptness and originality of the solutions given to the examples set during the course as well as the practical exercises handed in will be taken into account in the final marks.

Personal Tutorials:

During the hours of work. In the examination period a specific time-table will be posted.

Additional Information:

Due to the aims and contents of this subject, it is assumed that the students have taken the subject of Harbours and Coasts.

Syllabus:

1. **THE HARBOURS**

   Service area. Kinds. The property of harbours. Authorisations, concessions and port services. Special plans. Plans of uses.

2. **THE PORT TRAFFIC**

   Traffic of the principal ports. Shipping.

3. **THE STRUCTURES AND FACILITIES OF THE HARBOURS**

   Dimensioning of the flotation area. Maritime signalling.

4. **THE MARITIME TRANSPORT CONTRACT**

5. **THE USERS**

6. **TERMINAL MANAGEMENT AND OPERATIONS**

7. **GENERAL CARGO**

8. **GENERAL UNIFIED CARGO. CONTAINERISATION**

9. **SOLID BULKS**

10. **LIQUIDS BULKS**

11. **NON CONVENTIONAL DOCKS**

12. **THE LABOUR FORCE**

13. **THE HARBOURS PLANNING**

14. **THE PLANNING PROCESS**

15. **THE STRUCTURE OF SPANISH HARBOURS**

16. **THE ECONOMIC STRUCTURE**

Computer Aided Design and Visualization

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Luis A. Hernández Ibáñez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four – Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 CC**

Aims:

The course aims to teach the basis and theoretical fundamentals of Computer Aided Design, Advanced Visualization and Computer Animation applied to Civil Engineering. Praxis includes training on the use of CAD commercial packages to obtain blueprints and to generate realistic images of 3D models.

Teaching Organisation:

Classes last 4 hours/week including theory on computer graphics and praxis using CAD programs, with exercises and application to real cases for a better understanding of theoretical foundations. Students must elaborate a coursework related to the 2D and 3D representation of a real case.

Bibliography:

- *"A History of Engineering Drawing" Booker P; Northgate 1979.*
- *"Computer Graphics, Principles and Practice" Foley, J, et Al. Addison Wesley, 1990*
- *"Computer Graphics and Geometric Modelling for Engineers" Anand V.; J. Wiley S., 1993.*
- *"Mathematical Elements for Computer Graphics" Rogers D., Adams J.; McGraw-Hill, 1990.*
- *"Procedural Elements for Computer Graphics" Rogers D.; McGraw-Hill, 1985.*
- *"Advanced Animation and Rendering Techniques, Watt A.,Watt M.; Addison Wesley, 1992.*
- *"Graphics File Formats" Kay D., Levine J.; McGraw-Hill, 1995.*
- *"AutoCAD 2000" Dix, M. Riley, P; Prentice Hall, 2000*

Assessment:

The students must pass an examination and complete a course project.

Personal Tutorials:

Tutorials are held during office hours.

Additional Information:

A good knowledge of Technical Drawing and Descriptive Geometry is required.

Syllabus:

1. **History of Representation in Engineering**

   Introduction, History of representation methods Evolution of geometrical paradigms.

2. **Matrix Geometrical Operators**

   Matrix operators. 2D geometrical transformations. 2D geometrical transformations Projections. Perspective. Change of co-ordinate systems.

3. **Parametric curves and surfaces.**

   Interpolation and approximation. Continuity. Spline curves, Bèzier curves. B -spline curves. Base functions and knot vectors. Periodicity, uniformity. NURBS curves. Free form surfaces.

4. **Modelling systems.**

   Classification of modelling systems. Surface modelling. Polygonal meshes. Parametric meshes. Solid representation. Fundamentals of solid modelling theory. Primitives and boolean operators. Sweeping and lofting. Constructive solid Geometry (CSG). Boundary representation (B-rep). Spatial enumeration. Topographical modelling. Other specific modelling systems.

5. **Architecture of personal computers.**

   Graphic workstations. Components of personal computers. Calculus subsystem. Graphic subsystem. Storage subsystem. Graphic peripherals and multimedia systems. Network rendering.

6. **Computer visualisation.**

   Light-object interaction. Lambert model. Specular model. Phong model. Local illumination. Gouraud method. Phong Method. Global illumination. Ray Tracing. Radiosity. Hybrid methods. Materials, texture maps and procedural textures. Lights and shadows, types and properties. Cameras. Rendering. Properties of the final image.

7. **Graphic File Formats.**

   Coding and storage. Raster formats, description and features. Vector formats. Compression algorithms.

8. **Visualisation of large models**

   Large model. Efficient model. The rendering pipeline. Modelling strategies Actions on the geometry. Actions on the textures. Actions on the illumination. Adjusting rendering parameters for efficiency. Application on frame by frame and real-time animation.

PRACTICAL WORK

Learning and use of conventional programs of aided design, three- dimensional modelling and advanced visualisation.

Optimum Design of Structures

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Santiago Hernández Ibañez**
OTHER LECTURERS:	**Juan Carlos Perezzan Pardo**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To define the approach to the problem of optimum design of structures. To teach the methods of linear optimization and the most habitual non-linear methods. To describe the concept of analysis of sensibility and the methods of achieving it. To show applications of optimum design in different structural typologies. To inform students of the features of the computer programs of optimum design that currently exist.

Teaching Organization:

Theoretical lectures will be imparted for four hours a week and proposed problems will be solved in the practice papers. In the *Laboratory of Computer Aided Calculation of Structures* optimum designs of structures will be obtained through the programs ADS and COSMOS/M.

Bibliography:

- *"Métodos de diseño óptimo de estructuras", Santiago Hernández, Colegio de Ingenieros de Caminos, C. y P.*
- *"Numerical Optimization Techniques for Engineering Design: With Applications", G. N. Vanderplaats, McGraw- Hill.*
- *"Elements of structural Optimization", R.T. Haftka, Z. Gurdal amd M.P. Kamat, Kluwer Academic.*
- *"Introduction to Optimum Design". U. Kirsch, McGraw- Hill.*
- *"Introduction to Optimum Design", J Arora, McGraw- Hill..*

Assessment:

In order to pass the course it is necessary to have performed and passed the course work. Exams will be held at the end of June and September and in the final mark the mark of the exam and the course work it will be taken into account.

Personal Tutorials:

During working hours.

Additional Information:

It is very convenient to have studied Structures III.

Syllabus:

1. **APPROACH TO OPTIMUM DESIGN**
   The design in engineering. Conventional methods. Concepts associated with design: Fixed and variable factors. Conditions. Quality of design. Formulation of optimum design: Variables of design. Restrictions. Objective of functions. Historic evolution of optimum design.

2. **SIMPLE EXAMPLES OF OPTIMUM DESIGN OF STRUCTURES**
   Optimizing of structures . Optimizing simple elements. Optimizing of continuum.

3. **OPTIMIZING BY CRITERIA ASSIGNING**
   Criteria assigning for active conditions. Application of the Kuhn - Tucker condition.

4. **MATHEMATICAL CONTEXT OF OPTIMUM DESIGN**
   Convexity and non - convexity. Local and global minimums. Existence of regions of disjointed design. Methods of local and global optimizing.

5. **METHODS OF LINEAR PROGRAMMING.**
   Simple method: Primal formulation. Dual formulation. Application to the optimizing of structures of rigid junctions in plastic regime.

6. **UNCONDITIONED OPTIMIZING**
   Extremes of function of one variable. Minimums of functions of *n* variables. Methods of zero order: Conjugated directions. Methods of gradient. Newton's methods.

7. **CONDITIONED OPTIMIZING**
   Methods of penalty function. Method of efficient directions. Methods based on approximations: Sequences of linear problems; sequences of quadratic problems.

8. **DESCRIPTION OF A CODE OF MATHEMATIC OPTIMIZING: ADS**
   Introduction. Strategy options. Options of methods of optimizing. Options of one - dimensional search. Modalities of techniques of obtaining gradients.

9. **ANALYSIS OF SENSIBILITY**
   Concept of analysis of sensibility: Order and types. Direct methods. Methods based on the adjoined variable. Analysis of the sensibility of tensions. Analysis of sensibility of movements. Application to structures of articulated joints. Application to structures of rigid joints.

10. **OPTIMIZING OF STRUCTURES OF ARTICULATED JOINTS**
    Optimizing of sections. Optimizing of shape. Optimizing in elastic regime. Optimizing in plastic regime. Optimizing in theory of second order.

11. **OPTIMIZING OF STRUCTURES OF RIGID JUNCTIONS**
    Optimizing of shapes of transversal sections. Optimizing in elastic regime. Optimizing in plastic regime.

12. **DESCRIPTION OF A CODE OF OPTIMUM DESIGN OF STRUCTURE: GENESIS**
    Application to optimizing of bar structures. Application to optimizing the shape.

Railways Technical Operation

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Miguel Rodríguez Bugarín**
OTHER LECTURERS:	**Alfonso Orro Arcay, Margarita Novales Ordax**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know those specific aspects relative to railway terminals for passengers and goods. To identify and to differentiate the rolling equipment characteristics, as well as the specific phenomena involved in vehicle movements. To characterize the main elements of the electrification, signaling, security, communications and operation systems. To identify and differentiate the technical and commercial operations, as well as their suitability for certain situations. To describe the organization and administration of the railway activity.

Teaching Organization:

During 4 hours a week, theory lectures are imparted and numerical examples are solved. Technical visits are organized to railway installations in the region.

Bibliography:

- *"Ferrocarriles", García Díaz-de-Villegas, J.M. Publicaciones de la E.T.S. Ingenieros de Caminos, Santander, 2000.*
- *"Tratado de Ferrocarriles", Oliveros Rives, F., López Pita, A. y Mejía Puente, M., Editorial Rueda, Madrid, 1977.*
- *"Tratado de Explotación de Ferrocarriles (I)", Oliveros Rives, F., Rodríguez Menéndez, M. y Mejía Puente, M., Editorial Rueda, Madrid, 1983.*
- *"Operación de Trenes de Viajeros", García Álvarez, A., Cillero Hernández, A., Rodríguez Jericó, P., Fundación de los Ferrocarriles Españoles, Madrid, 1998.*

Assessment:

A final exam is held, with a theoretical part and another with numerical questions. To pass the course it is required to pass both parts.

Personal Tutorials:

In working hours.

Additional Information:

Syllabus:

I RAIL TRANSPORTATION TERMINALS

1. **Passenger stations**
2. **Goods stations**

II INTRODUCTION TO ROLLING EQIPMENT

3. **The rolling eqipment. Types of vehicles**

III TRAIN DYNAMICS

4. **Adherence and traction**
5. **Resistances and forces**
6. **Train braking**
7. **The rolling equipment in movement**

IV TRACTION

8. **Electric traction**
9. **The contact line and the return circuit**
10. **The locomotive. Mechanical part.**
11. **The locomotive. Electric and diesel traction**

V OPERATION

12. **Signaling**
13. **Introduction to interlocking**
14. **Communications**
15. **Operational systems**
16. **Traffic capacity**
17. **Fares**
18. **Environmental impact of railways**

VI RAIL SYSTEMS

19. **Underground**
20. **Light rail-line**
21. **High speed trains**
22. **Regional trains**
23. **Non-conventional trains**

Underground Hydrology

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Javier Samper Calvete**
OTHER LECTURERS:	**Ricardo Juncosa Rivera, Francisco Padilla Benítez and Jorge Molinero Huguet**
YEAR:	**4rd**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To give a general and balanced view of the basic and applied aspects of Underground Hydrology from the necessities of the civil engineer.

Teaching Organization:

This is a four- month course which consists of four hours per week grouped two by two. It is developed by lessons which combine a sufficient theoretical knowledge with the practical applicability of the material, and the commentary on real cases. Throughout the course a series of problems are given to the students to be solved. Once they are corrected, the problems are explained and commented on in the classroom. The latter is completed with laboratory sessions, and field trips.

Bibliography:

- *"Hidrología Subterránea" CUSTODIO, E.,LLAMAS, M.R., Editorial Omega, S.A., 1983*
- *•"Quantitative Hydrogeology", DE MARSILY,G. Academic Press. San Diego, 1987*
- *"Groundwater", FREZE, R.A.; CHERRY, J.A. Prentice Hall, 1979*
- *"Physical and Chemical Hydrogeology", DOMENICO P. and F. SCHWARTZ,1990.*
- *"Analysis and evaluation of pumping test data", KRUSEMAN, H.; DE RIDDER, J, Inter. Inst. For Land Reclamation and Improvement. Wageningen, Holanda, 1970*
- *"Applied hydrogeology", FETTER, C.W. J.R., Ch. E. Merrills Pub., 1980*
- *"Introduction to the groundwater modeling: finite difference and finite element methods", WANG, H.F.; ANDERSON, M.P., W.H. Freeman \& Co. San Francisco,1982*

Assessment:

To pass the exam it is necessary: to do the set exercises satisfactorily, to have carried out the field trips and laboratory practices correctly and to do an individual course project.

Personal Tutorials:

The lecturers post the weekly tutorial timetable at the beginning of the course.

Additional Information:

It is assumed that the student has passed previously the following subjects: Hydraulics and Hydrology I & II and Geology and Introduction to Geotechnical Engineering. Moreover, it is advisable that the students should have studied previously the subjects of Statistics and Numerical Calculus.

Syllabus:

1. **INTRODUCTION**
2. **THEORY OF THE FLOW OF UNDERGROUND WATER**

   Basic principles and fundamental equations for the knowledge and study of water flow through permeable media.

3. **FLOW IN AQUIFERS**

   Equations and methods, flow equations in aquifers, Dupuit hypothesis, pressure surfaces: layout and interpretation: pressure oscillations. Exploration techniques of underground waters. Flow through non-saturated zone. Relations surface waters - underground waters and marine waters.

4. **EXPLORATION AND MANAGEMENT OF AQUIFERS**

   Exploration methods and construction of uptakes, methods for assessing reserves and underground resources and the different hydrological implements of management of aquifers. Techniques of exploitation of waters. Management of aquifers.

5. **HYDRAULICS OF UPTAKES**

   Vertical and horizontal uptakes.

6. **HYDROCHEMICS AND QUALITY OF UNDERGROUND WATERS**

   Hydrochemics of underground waters, transport processes of solubles and contamination of aquifers.

7. **NUMERIC MODELIZATION OF AQUIFERS**

   Numerical methods (Finite Differences and Finite Elements) to resolve the general equation of flow and the flow in aquifers. Calibration. Numerical methods to resolve the equation of transport of solubles in aquifers. Practice sessions with a calculation code.

8. **APPLICATION OF UNDERGROUND HYDROLOGY TO CIVIL ENGINEERING AND REAL CASES**

History of Art

DEPARTMENT:	**Composition**
LECTURER IN CHARGE:	**Josefina Cerviño Lago**
OTHER LECTURERS:	
YEAR:	**3rd**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To know and understand the different artistic styles, in relation to the historic, economic and social context of the epoch.

Teaching Organisation:

For four hours per week theoretical and practical classes are given.

Bibliography:

- *"Historia del Arte", Gombrich E. H.; Alianza, Madrid, 1997.*
- *"Arquitectura de la prehistoria a la postmodernidad". Trachtenberg M.H., Man I. ;Akal, Madrid, 1990.*
- *"El Arte Moderno", Argan G. C.; Akal, Madrid, 1991.*
- *"Historia General del Arte", Janson H.W.; Alianza, Madrid, 1995.*

The appropriate bibliography for each theme will be indicated.

Assessment:

Two final exams will be held, one in June and the other in September.

Personal Tutorials:

During working hours.

Additional Information:

Syllabus:

1. **THEORY AND FUNCTION OF ART**

2. **GREEK ARCHITECTURE**
   The Temple and its orders. Sculpture. Hellenism.

3. **ROMAN ARCHITECTURE**
   The city: typology and function of public buildings. The sculpture. The mosaic and painting.

4. **PALEO- CHRISTIAN AND BYZANTINE ART**
   The basilica. Sculpture and mosaics.

5. **PRE- ROMANIC ART**
   Hispanic- Godo art, Asturian and mozarabe. The miniature.

6. **CONTRIBUTIONS OF ISLAMIC ART**
   The mesquite. Al- Andalus. The decorative arts.

7. **ROMANIC ART**
   The architecture of the pilgrims way. The cathedral of Santiago. Romanic plastic art. Spanish Roman painting.

8. **GOTHIC ART**
   The cathedral: structure, space and facades. Sculpture. Glasswork and painting. Spanish gothic. Mudejar art.

9. **THE RENAISSANCE**
   The Italian 14th Century "quatrocento". The second generation. The classical period. Venetian painting. The spread of the Renaissance through Europe.

10. **THE RENAISSANCE IN SPAIN**
    Mannerism. Philip II and The Escorial. El Greco. Galicia.

11. **BAROQUE EUROPEAN ARCHITECTURE**
    The plastic arts. Baroque urbanism in Spain. Compostela Baroque.

12. **FROM ROCOCO TO NEO -CLASSICISM**
    Goya.

13. **THE ARCHITECTURE OF THE 19TH CENTURY**
    The Chicago School. Gaudí. Evolution of the figurative arts up to expressionism.

14. **IMPRESSIONISM AND POST- IMPRESSIONISM**

15. **THE AVANT-GARDE MOVEMENTS OF THE 20TH CENTURY**
    Fauvism and Expressionism. Abstraction. Cubism. Picasso. Futurism. Dada and Surrealism. Other artistic movements. Spain and Galicia.

16. **ARCHITECTURE OF THE 20TH CENTURY**
    The problems and development of contemporary urbanism.

17. **THE ARTISTIC PANORAMA SINCE 1945**
    The New materials. The Galicia of the end of the century.

18. **ART AND THE NEW TECHNOLOGIES**
    Video and computer. Photography. The art markets.

Engineering of Urban Sewage Systems

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Joaquín Suárez López**
OTHER LECTURERS:	**Alfredo Jácome Burgos**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To improve the students' capacity for design and project in solutions of the sewage systems, drainage and advanced management of the waste waters of the city. To make progress in the knowledge of advanced processes of purification for the elimination of nutrients and to know the strategies of management of waters in rain time.

Teaching Organization:

Three types of activities will be carried out: theoretical lessons, practical lectures on design and dimensioning of solutions of the sewage system, drainage and purifying and practice sessions with computer programs.

Bibliography:

- *"Curso de hidrología urbana", Universidad Politécnica de Cataluña, Barcelona, Noviembre de 1995.*
- *"Instrucción de carreteras 5.2.I.C"; MOPU, Madrid, 1990.*
- *"Introduction to Hydrology"; Viessman, W., Lewis, G., Knapp, J.; Harper, New York, 1989.*
- *"Ingeniería de aguas Residuales. Tratamiento, vertido y reutilización"; Metcalf/&Eddy, Third Edition, 1995; ISBN 84-481- 1607-0.*
- *"Ingeniería de Aguas Residuales. Redes de alcantarillado y bombeo"; Metcalf/& Eddy,; 1995; ISBN 84-481-1550-3.*
- *"Curso sobre tratamiento de aguas residuales.y explotación de estaciones depuradoras", two volumes, CEDES, Centro de Estudios y Experimentación de Obras Públicas, Ministerio de Obras Públicas y Transportes, Gabinete de Formación y Documentación, Madrid 1982.*
- *"Termodinámica". Wark K. , D.E. Richards. Mc Graw-Hill Interamericana de España. Madrid 2001 (sixth edition).*
- *"Tratamiento biológico de las aguas residuales", Ronzano, E., Dapena, J.L.; PRIDESA, Ediciones Díaz de Santos; 1995, ISBN 84-7978-202- I.*

Assessment:

Three compulsory works and three partial exams will be carried out. Finally an end-of-the-year exam will be held.

Personal Tutorials:

During working hours (previous appointment with the lecturer).

Additional Information:

A knowledge of hydraulics and Environmental Engineering is required.

Syllabus:

1. **SYSTEMS OF INTEGRAL AND INTEGRATED SEWAGE SYSTEM**
   INTRODUCTION. PHILOSOPHY. OBJECTIVES. ADVANCED MANAGEMENT OF URBAN SEWAGE SYSTEM. TOOLS FOR DESIGN AND PLANNING.

2. **URBAN DRAINAGE**
   PRECIPITATION: IDF curves. Hyetogram of calculation. Construction of synthetic hyetogram. Losses. Net –rain. TRANSFORMATION RAIN RAINOFF: Rational method. Unitary Hyetogram. Methods based on the equations of hydraulics. HYDRAULICS OF COLLECTORS: Studies of permanent and non- permanent regime. Outline conditions. Crotches. Criteria of design. TYPOLOGY OF INFRASTRUCTURES OF DRAINAGE AND URBAN SEWAGE SYSTEM: Dimensions of wells, galleries and collectors. Particular works. New trends in urban drainage. CALCULATION BY MEANS OF COMMERCIAL MODELS: Transformation models of rain run- off and hydraulics of collectors. Use of SWMM.

3. **BIOFILMS TREATMENT OF WASTE WATERS**
   Biological processes. BASIC TYPOLOGY OF BIOLOGICAL PROCESSES. THEORETICAL BASES OF BIOLOGICAL PROCESSES: Study of populations. Biokinetics of elimination of substratum. Biokinetics of growth of biomass. Biokinetics of consumption of oxygen. ANALYSIS OF THE BIOFILM: Formation and accumulation. Composition. Physical characteristics. Transformation of materials and reaction. Models of simulation. TYPOLOGY OF AEROBIC BIOFILM PROCESSES. BACTERIAL BEDS: Concept. Description of process. Supporting method. Deposit. Feeding of waste water. Exit of waste water. Ventilation. Cortical history and new focus. CARBONOUS OXIDATION BEDS: Theoretical analysis. Design. Applications. NITRIFICATION BEDS: tertiary nitrification.- Design considerations. Proceedings of design. Joint elimination of DBO and N- NH4+.- Aspects and criteria of design. Proceedings of design. BIODISCS: Description. Typology. Theoretical analysis. Nitrification biodiscs. Design. Application. AIREATED BIOFILTERS: Description. Typology. Advantages. Design. Applications. SUBMERGED AIREATED BEDS: Description. Tipology. Advantages. Design. Applications. ANALYSIS OF THE ADVANTAGES AND INCONVENIENCES OF THE BIOFILM PROCESSES. Comparison between biofilm processes. Advantages of active sludge.

4. **PROCESSES OF ELIMINATION OF NUTRIENTS BASED IN SUSPENDED BIOMASS. ELIMINATION OF NITROGEN**
   BIOLOGICAL TREATMENTS. Fundamentals. CONVENTIONAL ACTIVE SLUDGES. Understanding and design of a plant. CYCLE OF NITROGEN. Nitrogen in ecosystems. Forms of nitrogen in AR. Problems of nitrogen forms of contaminants. BIOLOGICAL NITRIFICATION. Description of the process. Classification of the processes of nitrification. Carbonic oxidation and nitrification in one stage. DENITRIFICATION. Basic concepts. Dimensioning. PROCESSES OF NITRIFICATION-DENITRIFICATION MOST USED. General parameters of design.

5. **ELIMINATION OF PHOSPHOROUS**
   INTRODUCTION. Cycle of phosphorus in ecosystems. Forms of phosphorus in waste water. Problems as contaminant. CHEMICAL PRECIPITATION FOR THE ELIMINATION OF PHOSPOROUS. Typical lines of process. Chemistry of the elimination of phosphates. Effects on the treatment of sludges. DEPHOSPHATATION BY BIOLOGICAL MEANS. Bases of the processes. Basic configurations. Treatment of sludges. Dimensioning. CONCLUSIONS.

6. **CONTAMINATION OF URBAN RUN-OFF WATER. NEW TECHNIQUES OF MANAGEMENT OF RAIN WATERS.**
   Problems. Contamination of urban runoff water. Problems of impacts of receptor medium. Management techniques. Integration of the sewage systems.

7. **DESIGN OF BIOLOGICAL PROCESSES WITH THE AID OF COMPUTER PROGRAMS.**
   FORMULATION OF A MODEL. Equations of balances of materials. Equations of transport of materials. Simplifying hypotheses. Stoichiometry matrix. Model components. Characteristics of the wastewaters against the construction of a kinetic model. AQUASIM 2.0: Characteristics. Description of types of variables. Implementation. Practical case: Application to bacterial beds. EDAR 1.0: Characteristics. Implementation. Practical case: application to a system of active sludge with nitrification/ denitrification.

Materials and Constructive Systems

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Cristina Vázquez Herrero, Manuel F. Herrador Barrios**
OTHER LECTURERS:	**Fernando Martínez Abella**
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To improve the knowledge in Construction Engineering covering new construction materials, analysis methods and construction of particular structural elements and structure pathologies and repair.

Teaching Organization:

Theoretical and practical lectures are complemented with worksite visits, special topic seminars, laboratory work and conferences by invited building designers and specialists.

Bibliography:

- *"Concrete Technology. New Trends, Industrial Applications", Proceedings of the International Rilem Workshop, edited by A. Aguado, R. Gettu y S.P. Shah, E \& FN Spon Chapman \& Hall, London, 1995.*
- *"Hormigones de Alta Resistencia", GT I/2 del GEHO, GEHO Bulletin 20 , Madrid, 1997.*
- *"Patología de Estructuras de Hormigón Armado y Pretensado", J. Calavera, INTEMAC, Madrid, 1996.*
- *"El Estado del Arte en Reparación y Refuerzo de Estructuras de Hormigón", Various authors, GEHO, Madrid, 1995.*
- *"Sostenimiento del Hormigón", TMC, Madrid, 1995.*
- *Other papers and specific codes referred to at the beginning of each topic lecture.*

Assessment:

A compulsory laboratory project must be developed and publicly presented.

Personal Tutorials:

To be posted at the beginning of the term.

Additional Information:

Students attending this course are supposed to have passed *Construction Materials* and are simultaneously following the *Reinforced and Prestressed Concrete I* course.

Syllabus:

1. **SPECIAL MATERIALS**
   CEMENT– BASED MATERIALS (Mechanical properties, construction and applications): Lightweight Concrete, High Performance Concrete, Fiber Reinforced Concrete, other cement-based materials. METALLIC MATERIALS (mechanical properties, production and applications): Special steels, Aluminum, other metallic materials. COMPOSITE MATERIALS (mechanical properties, production and applications): Glass Fiber, Carbon Fiber, Aramide Fiber, Thermostable Resins and Thermoplastic Matrices.

2. **CONSTRUCTIVE SYSTEMS**
   Concrete support: scaffoldings and forms. Construction procedures: building, dams, other structural elements.

3. **PATHOLOGY AND REPAIR OF CONCRETE AND STEEL STRUCTURES**
   PATHOLOGY: State of the art. Causes of pathology (attacks to concrete and steel, resistance decrease, project, materials, handling and maintenance flaws). Impact of pathology in durability and capacity. REPAIR: Structure diagnosis. Repair materials. Repair of different structural elements.

Rock Mechanics

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Jordi Delgado Martín**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To introduce the student to basic knowledge in relation to rock mechanics.

Teaching Organization:

Lectures in theory, practical lessons and selected field trips.

Bibliography:

- *"Underground excavations in Rocks", E. Hoek and E.T. Brown, Institution of Mining and Metallurgy, 1980.*
- *"Rock Slope Engineering", E. Hoek and J.W. Bray, Institution of Mining and Metallurgy, 1981.*
- *"Introduction to Rock Mechanics", R.E. Goodman, Wiley, 1989.*
- *"Stereographic projection techniques", P.R. Leyshon and R.J. Lisle, Butterworth, 1996.*

Assessment:

Evaluation will be based on tests covering the knowledge acquired on the discipline, both in theoretical and practical aspects. In the final marks active participation in the lectures and field sessions will be taken into account. A report related to the subjects of the course could be asked for.

Personal Tutorials:

To be convened with the lecturer.

Additional Information:

It is necessary to be familiar with concepts of geology and geotechnics given as a part of the courses *Geology and Introduction to Geotechnical Engineering* and *Geotechnical Engineering II.*

Syllabus :

1. **INTRODUCTION.**
   Presentation. Geological risk. Risk hypotheses. Risk classification. Geological risk assessment in Spain.

2. **DESCRIPTION OF THE STRUCTURAL DOMAIN.**
   Basic petrology. Elemental tectonics. The concepts of rock massif and rock matrix. Anisotropy in rock massifs. Elemental topics on micro tectonics. Field work methodology. The analysis of rock massifs. Geological data collection. Sampling and sample representativity.

3. **GRAPHICAL REPRESENTATION OF DISCONTINUITIES.**
   Stereographic projection. Polar projection. Stereonets. Poles and stereograms. Pole counting. True and apparent dip. Intersection among planes. Line among lines. Wedge analyses. Minor circles. Borehole problems.

4. **"IN SITU" STRESSES. ORIGIN AND QUANTIFICATION.**
   Rheological behavior of geological materials. Stress in rock massifs. Origin of short, intermediate and long duration stresses. Stress measurement: Hydraulic fracturing and flat-jack tests. Overcoring. Measurements made directly on the rock surface.

5. **MATRIX ROCK PROPERTIES. TESTS. TENSO-DEFORMATIONAL BEHAVIOR OF THE ROCK MATRIX.**
   Identification tests. Classification tests. Alterability/durability tests. Mechanical tests. Fragile vs. ductile behavior. Dilatancy. Confining pressure effect. The water effect: effective stress. The effect of stiffness in test machines. Conceptual model for micro joint/joint propagation. Failure concept. Hoek and Brown Criterion. Joints and anisotropy.

6. **MECHANICAL BEHAVIOR OF JOINTS.**
   Experimental study. Compression behavior. Shear behavior. Joint strength. Patton's Law. Jaeger's Criteria. Barton's Criteria. Hoek's Criteria. Ladanyi-Archambault's Criteria. The influence of fillings, cements, water, rock bridges, roughness heterogeneity on the strength of joints.

7. **ROCK MASSIF STRENGTH.**
   The role of rock matrix. The role of joints. Matrix-joint integration models. Hoek and Brown model. Geomechanical classification: Barton, Bieniawski.

8. **SURVEY TECHNIQUES.**
   Electromagnetic spectra and teledetection. Aerial photographs. Geometric description of stereophotographic pairs. Information strips in aerial photographs. Scale determination. Identification of valleys and watersheds. Identification of lineations. Identification of geological materials. Geological structures. Land management. Geophysical techniques: electrical methods, seismic and electromagnetic methods. Mechanical techniques: piezometers, Lugeon test, dilatometers, hydrofracturing, "in situ" direct shear test.

9. **CALCULATION METHODS.**
   Graphical methods. Kinematic methods. Numerical methods. Limit equilibrium methods. Plane failure. Circular failure. Toppling.

10. **WATER FLOW IN ROCK MASSIFS.**
    Equivalent permeability tensor. Cubic Law. Additional conceptual models: discrete fracture networks, hybrid methods.

Decision Taking in Engineering

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Ramón Martul Álvarez de Neyra and Manuel Casteleiro Maldonado**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To show the basic criteria which were used in a rational and objective way at the time of taking decisions inside a group of possibilities and, besides to acquire the exact knowledge in order to do analysis and rational criticism of actions.

Teaching Organization:

The teaching activity is based on four hours per week, on theoretical and practical lessons and on solving the practical exercises.

Bibliography:

- *"Probability, Statistics and Decision for Civil Engineers", Benjamin J.R. and Cornell C. McGraw-Hill, New York, 1970*
- *"Teoría de la decisión", White D.J. Alianza Editorial, Madrid, 1990*
- *"Introducción a la teoría de juegos",Morton D. Davis. Alianza Editorial, Madrid,1986*
- *"Teoría de los juegos (6 volúmenes)", Girón González-Torre F.J. UNED, Madrid, 1997*
- *"Teoría de la Decisión (6 volúmenes)", Infante Macias R.UNED, Madrid, 1978*
- *"Programación Lineal : Metodología and problemas", Mocholi Arce, M.; Sala Garrido, R., Tebar Editorial Flores, Albacete, 1993*
- *"Principios de la teoría de la decisión", Lindley D.V. Ed. Vincens-Vives ., Barcelona,1977.*
- *"Metódos de diseño optimo de estructuras", Hernández S., Colegio I.C.C.P., Madrid, 1990*
- *"Teoría de la decisión multicriterio: Conceptos, técnicas y aplicaciones" Romero C. Alianza Unversidad, Madrid, 1993*
- *"Teoría de Juegos",Binmore K. McGraw-Hill, Madrid, 1994*

Assessment:

It is essential to have done the works set along the course. The assessment is based on two final exams, June and September. The course can also be passed doing the works set by the teachers of the subject before the 30th of June.

Personal Tutorials:

A specific timetable will be posted.

Additional Information:

It is important that students had attended or are attending the *Statistics* course of the 3rd year. It is also advisable, though not indispensable, to have some basic knowledge in linear programming.

Syllabus:

1. GAMES

Previous concepts. Normal form. Bipersonal games of null total. Extensions of the concept of strategy.

2. DECISIONS IN ATMOSPHERE OF UNCERTAINTY

Principles of rationality. Criteria of decision: Wald, Maximax, Minimax, Hurwicz and Savage. Critique of the principles: Rubin's principle, principle of insufficient reason.

3. DECISIONS WITHOUT EXPERIMENTATION

Bayes' Decision. Function of loss. Bayes' risk. Geometric Interpretation. Calculation of minimax decisions: move favourable distribution. Alternatives to minimax.

4. DECISIONS WITH EXPERIMENTATION

Atmosphere of risk: Bayes' Risk and Decision, Atmosphere of uncertainty. Scrambling and minimax decisions. Function of cost associated with experimentation.

5. SYNTHESIS OF JUDGEMENTS

Approaching the problem. Functions of aggregation. Synthesis of uniform opinions. Generalization to other distributions.

Urbanism I

DEPARTMENT:	**Architectonic Projects and Urbanism**
LECTURER IN CHARGE:	**Juan Creus Andrade**
OTHER LECTURERS:	**Carlos Nárdiz Ortiz**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To introduce the student to the knowledge of urbanism, understood as the science which orders the territory and the activities which are carried out on it. The course is based on the analysis of the models and elements of organization and will serve as introduction and complement to the rest of the subjects in the field.

Teaching Organization:

For 4 hours a week, theoretical and practical lectures will be imparted. The students will analyze different proposals of organization and will elaborate their own using the models and elements studied.

Bibliography:

- *"El medio rural y la práctica del urbanismo en Galicia: contradicciones", Manuel Gallego Jorreto.Edicións Galaxia, A Coruña , 1975.*
- *"Resumen histórico del urbanismo en España", García Bellido y otros, Instituto de la Administración Local, Madrid, 1997.*
- *"Historia del Urbanismo en Europa 1750-1960", Benedetto Gravagnolo, Ediciones Akal, Madrid, 1998.*
- *"La práctica del urbanismo", Sir Raymon Unwin, Gustavo Gili, Barcelona 1984.*
- *"Diseño de la ciudad-5", Leonardo Benévolo, Gustavo Gili, Barcelona 1982.*
- *"Las formas de crecimiento urbano", Manuel de Solá Morales i Rubió, Ediciones UPC, Barcelona, 1997.*
- *"Nuevos territorios, nuevos paisajes", Varios autores, Actar, Barcelona 1997.*

Assessment:

Continuous assessment, through the following up of the course work and explanations of the students.

Personal Tutorials:

They will be fixed in mutual agreement with the students.

Additional Information:

Syllabus:

1. **URBANIZATION OF TERRITORY**
2. **TERRITORIAL STRUCTURE OF RURAL AREAS.**
3. **INTERPRETATION OF URBANISTIC INFORMATION**
4. **RESIDENTIAL FORMS OF THE CITY OF THE 18TH AND 19TH CENTURY**
5. **PROPOSALS OF NEW MODELS OF THE CITY**
6. **RESIDENTIAL FORMS OF MODERN MOVEMENT**
7. **FORMS OF GROWTH OF THE CURRENT CITY**
8. **REGULATION OF ROADS AND BUILDING IN RESIDENTIAL AREAS**
9. **REGULATION OF ROADS AND BUILDING IN INDUSTRIAL AREAS**
10. **ORDINANCES OF BUILDING AND ORGANIZATION**
11. **PUBLIC SPACE OF THE CITY**
12. **INSTALLATIONS OF THE CITY**
13. **THE OBJECTIVES OF URBAN PLANNING**

Roads and Airports II

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Ignacio Pérez Pérez**
OTHER LECTURERS:	
YEAR:	**4th**
TYPE:	**Four- Month option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To amplify the knowledge of the layout and the pavement design, acquired in the subject of Roads and Airports. The methods of exploitation of roads. The blocks which the subject comprises are: 1) design of intersections and links, 2) concrete pavements, 3) empirical and analytical methods of dimensioning of surfaces , 4) preservation of roads, 5) legislation and 6) airports

Teaching Organization:

Theoretical lectures are taught and practical exercises of the set themes are put forward for four hours a week. In parallel laboratory practices referring to the basic tests explained in the theoretical lectures are carried out. Didactic visits to works and acts related to the aims of the subject are carried out.

Bibliography:

- *"Normativa vigente del Ministerio de Fomento", Instrucción de carreteras, PG-3/75 modificado, Instrucción de Drenaje 5.2.I.C.*
- *"Colección de libros: Tráfico, explanaciones y drenajes, trazado de carreteras, y firmes", Kraemer C., E.T.S de Ingenieros de Caminos de Madrid..*
- *"Carreteras Urbanas. Recomendaciones para su planteamiento y proyecto". MOPT.*
- *"Pavement Analysis and Design". Yang H. Huang*
- *"Proyecto y Construcción de Carreteras". G. Jeuffroy.*
- *"Planificación y diseño de aeropuertos". Robert Horonjeff*
- *Magazines "CEDEX" and "Carreteras"*

Assessment:

The assessment of the subject is carried out by means of a final exam and the participation in the lectures. The submitting of the set practices is also taken into account.

Personal Tutorials:

Lecturers fix the personal tutorials weekly, in mutual agreement with the students.

Additional Information:

Basic knowledge of construction materials, traffic engineering as well as road design is assumed.

Syllabus:

1. **AMPLIFICATION OF LAYOUT OF ROADS**
   The design of the cross section. The design and layout of junctions: General concepts. Intersections, Roundabouts, Links. Urban roads.

2. **SIGNALING OF ROADS.**
   Horizontal and vertical signaling. Laying down beacons. Defense elements. Director signaling plans.

3. **STRUCTURAL ANALYSIS OF ROAD SURFACES**
   Empirical methods. Analytic methods.

4. **CONSERVATION OF ROADS**
   Current state of the technique. Inventory of roads. Conservation of the levels and drainage. Conservation of road surfaces. Conservation of structures. Future tendencies.

5. **ROAD LEGISLATION**

6. **AIRPORTS**
   Airport systems. Road surfaces in airports. Layout of runways, lanes and platforms.

Water Resources and Hydraulic Planning

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Francisco Padilla Benítez**
OTHER LECTURERS:	**Ricardo Juncosa Rivera and Rodrigo del Hoyo Fernández-Gago**
YEAR:	**4th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To provide the students with the principles of water resources assessment and the hydraulic planning tools.

Teaching Organization:

The theoretical teaching of the course consists of 4 hours per week that will be completed with conferences on experimental and actual cases by invited specialists. During the academic year the lecturers will distribute several exercises about the subjects of the course in order to evaluate the students efficiency. The students should also carry out a team project on hydrologic planning that will also contribute to the assessment of the course.

Bibliography:

- *"Conceptos y métodos para la planificación hidrológica", Andreu J., Ed. CIMNE, 1993.*
- *"Principles of Water Resources Planning", Goodman A., Prentice-Hall, 1984.*
- *"Recursos Hidráulicos y su Planificación", Liria J. y Sáinz J.A., Apuntes de la ETSICCP de Santander, 1982.*
- *"Water Resource Systems Planning and Analysis", Loucks D., Stedinger J. y Haith D., Prentice-Hall, 1981.*
- *"El Libro Blanco del Agua en España", MMA, Madrid, 2000.*
- *"Planificación Hidráulica", Vallarino E., Apuntes de la ETSICCP de Madrid, 1980.*
- *"Modelos matemáticos para la evaluación de los recursos hídricos",Teodoro Estrela. CEDEX, 1993*
- *"Recomendaciones para el cálculo hidrometeorológico de avenidas", F. Javier Ferrer Polo, 1993*

Assessment:

The final qualification of the course will be calculated by means of the partial evaluations obtained in the exercises and projects carried out by the students.

Personal Tutorials:

At the beginning of the academic year the lecturers will notify the schedule of the three hours per week personal tutorials.

Additional Information:

Syllabus:

1. INTRODUCTION
Water resources. Water resources integrated planning. Water resources planning and land management.

2. WATER RESOURCES
The drainage basing Surface water and ground water. Water uses. Water quality. Planning objectives. Planning data.

3. WATER RESOURCES ASSESSMENT
The drainage basing resource balance. Restitution of gauging flow data. Linearity, superimposition and influence functions. Simulation strategies. Methods of assessment.

4. STUDY OF GROUND WATER
Assessment of ground water storage and resources. Water balances in the soil, unsaturated zone and aquifers. Ground water discharges assessment. Ground water exploitation and related problems. Overexploitation. The complete simulation and the simulation through superimposition. The aquifer simulation in the management models. The aggregated and distributed models. Validation and calibration models. Considerations about the ground water conditions of simulation. Ground water models.

5. STUDY OF SURFACE WATER
Necessary data. Methods of contrast and verification. Simple methodologies of data analysis and treatment: simple and multiple regression, revision and planning of a gauge station network. Deterministic models: aggregated and distributed. Stochastic models. Autoregressive models. Historic and synthetic series. Data base. Floods, drought, water leakage, ecological flows. Hydrologic models.

6. WATER DEMAND
Types of water demands: urban, industrial, agricultural, hydroelectric, ecological, recreational. Characteristics. Future demand prevision. Volume and distribution of future demand. Decision-making about the objectives of water resources demand.

7. WATER RESOURCE SYSTEMS
Principles. The guarantee concept. Theory and calculation of the guaranty. Other countries criteria. New criteria for the system efficiency assessment: vulnerability, resilience and robustness. Optimization. Priorities and restrictions. Objective function. Theory of optimization. Reservoir optimization. Linear programming. Methodologies applied to the regulation studies.

8. EXPLOITATION METHODS
Regulation elements, surface and underground reservoirs. The hydraulic potential and the assessment of the hydroelectric energy. Turbines and hydroelectric power station elements. Design. Exploitation strategies. Priority of demand. Restrictions to the exploitation of the system.

9. JOINT USE
Surface water-ground water relationships. Artificial recharge. The water recharge assessment into aquifers. Conjunctive use. Typology of the conjunctive use. World-wide panorama. Types of models.

10. QUALITY AND POLLUTION
Quality and pollution of surface water: Autopurification potential, Eutrophication. Quality and pollution of ground water: Autopurification potential , non-saturated zone. Ground water-sea water. Treatment and purification: types of plants, re-used water. Types of models. Analysis of actual cases.

11. WATER RESOURCES PLANNING IN SPAIN
The Water Law of 1985. Regulations. The Law experiences. Water resources planning. The National Water Resources Plan.

Typology of Structures

DEPARTMENT:	**Construction Technology**
LECTURER IN CHARGE:	**Santiago Hernández Ibáñez**
OTHER LECTURERS:	
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To describe the most used structural schemes in engineering. To analyze historical background and its evolution through time. To understand the interactions between the structural typology, the existing materials of construction in each historical time and the calculation methods.

Teaching Organization:

The teaching activity is based on theoretical lessons four hours per week and on solving structural models using computer programs.

Bibliography:

- *"Razón de ser de los tipos estructurales", E. Torroja, CSIC.*
- *"Structures", J.E. Gordon, Penguin.*
- *"Torri", Heinle, E., Leonhardt, F., Mondadori.*
- *"Bridges", G. Outerbridge, H.N. Abrams Publishers.*
- *"Puentes y sus constructores", Steinman, D.B., Watson, S.R., Colegio de I.C.C.P*
- *"The Tower and the Bridge", , D.P. Billington, Priceton University Press.*

Assessment:

In order to pass it is necessary to submit the proposed coursework. End-of-the-year exams are held in June and September.

Personal Tutorials:

During working hours.

Additional Information:

It is assumed that the students know the computer programs of calculation of structures by the Finite Element Method.

Syllabus:

1. ASPECTS ASSOCIATED WITH THE PROCESS OF DESIGN

Materials. Admissible tensions: Construction techniques. Methods and models of calculation. Historical experience.

2. MASSIVE STRUCTURES

Materials. Static schemes. Behavior of materials. Egyptian and Mayan pyramids. Roman constructions. Obelisks. Chimneys. Gravity dams. Loose material dams.

3. THE BEAM

Prehistoric and classical examples. Cantilevers. Continuous beams. Continuous beams on elastic supports.

4. THE ARCH

Natural arches. Arches in classical constructions. Muslim and medieval arches. Gothic constructions. Arch bridges: Materials used. Dimensioning. Arches for roof structures.

5. THE LATTICE

Materials. Working scheme. Historical evolution. Roof trusses. Trussed bridges. Three-dimensional frameworks for roofs. Relay towers. Antennas.

6. PORTICOS

Structural behavior. Materials. Processes of calculation. Models of absorption of forces. Building structures. Maritime structures. Particular constructions.

7. SHEETS

Materials. Structural behavior. Sheets in classical Roman, Byzantine, and Muslim architecture. Renaissance and neoclassical sheets. Recent examples. Vault dam. Recipients to pressure.

8. SLABS

Materials. Structural behavior. Methods of calculation. Roofs. Bridge decks. Curved slabs.

9. PARTICULAR LOADS IN STRUCTURES

Earthquakes. Types of actions. Scales of intensity. Effects on buildings. Effects on dams. Anti-seismic constructions. Wind action on structures. Wind-structure interaction. Aeroelasticity.

10. FORM AND FUNCTION

Congruence between actions and formal structures. Optimizing the design. Examples in nature.

Landscape in Engineering

DEPARTMENT:	**Proyectos Arquitectónicos y Urbanismo**
LECTURER IN CHARGE:	**Carlos Nárdiz Ortiz**
OTHER LECTURERS:	
YEAR:	**3rd**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

The subject deals with confronting the student with the project of an engineering work from the scale of the place, in which he intervenes and transforms. The landscape which the student studies in this sense, it is not only the natural one but also the rural, the urban and the one created and transformed by the work of engineering itself, with which is related perceptively and through the elements of which it is composed and which characterize it.

Teaching Organization:

The course has a theoretical component exp ressed in the syllabus of the subject and a practical component which tries to confront the student with the previous approaches to the project through the language of reality itself.

Bibliography:

- *"I Jornadas Internacionales sobre Paisajismo". Santiago de Compostela 1991. Colegio de Ingenieros de Caminos, C. y P. de Galicia, Xunta de Galicia.*
- *"El Pensamiento Estético de los Ingenieros. Funcionalidad y Belleza",Discurso de José Antonio Fernández Ordóñez La Real Academia de Bellas Artes de San Fernando, Madrid, 1990*
- *"Ingeniería Civil y Medio Ambiente",CEOTMA MOPU. Series Monográficas10. 1981*
- *"El Paisaje",Escribano Bombin, M.y otros. Serie Unidades Temáticas Ambientales MOPT 1991*
- *"Ponts, Puentes",Fritz Leonhardt. Press Polytechnique Romands 1982*
- *"El diseño de las Vías Urbanas", Jim. Mc Cluskey 1992. Ed. Gustavo Gili 1985*

Assessment:

The assessment is based on a practical exercise in which the students identify the natural and artificial components which typify the landscape; they also do a visual and aesthetic analysis of the quality of the contents and study the alternatives to the necessary interventions which existed in order to restore it.

Personal Tutorials:

During working hours, and a one day tutorial hour is established to correct the practical exercises.

Additional Information:

The one derived from the study of the place, and the engineering work which transforms it.

Syllabus:

1. **ABILITY OF THE ENGINEER CONFRONTING NATURE**
2. **SCALES OF APPROXIMATION TO LANDSCAPE OF ENGINEERING**
3. **METHODS OF ANALYSIS AND ASSESSMENT OF THE LANDSCAPE**
4. **THE NATURAL LANDSCAPE**
5. **THE RURAL LANDSCAPE**
6. **THE URBAN LANDSCAPE**
7. **THE LANDSCAPE OF THE BRIDGE**
8. **THE LANDSCAPE OF THE ROAD**
9. **THE LANDSCAPE OF PORTS**
10. **THE COASTAL LANDSCAPE**
11. **THE FLUVIAL LANDSCAPE**

Transport Planning

DEPARTMENT:	**Mathematical and Representation Methods**
LECTURER IN CHARGE:	**Alfonso Orro Arcay**
OTHER LECTURERS:	**Margarita Novales Ordax**
YEAR:	**5th**
TYPE:	**Four- Month Option**
CREDITS:	**4 hours per week. 6 CC. 4 EC.**

Aims:

To explain the essential features of Transport Planning: The Planning Process. Spanish and European Transport Politics. Planning Studies. Transport Models. Transport Project Evaluation and Choice.

Teaching Organization:

The theoretical lectures are carried out together with the solving of some examples and practical problems 4 hours per week.

Bibliography:

- *"Modelling Transport 2nd Ed.", Ortúzar, J de D., Willumsen, L.G.. John Wiley & Sons, West Sussex (England) 1994.*
- *"Modelos de Demanda de Transporte 2ª Edición", Ortúzar, J. de D. Alfaomega, Ed. Universidad Católica de Chile. México, 2000*
- *"Manual para la evaluación de inversiones de transporte en las ciudades", AA.VV. Centro de Publicaciones Mº de Fomento, Madrid, 1996.*
- *"Transportation Planning Handbook", AA. VV. Institute of Transportation Engineers. Prentice Hall, New Jersey, 1992*
- *"Transportes. Un enfoque integral", Izquierdo, R. Publicaciones del Colegio de Ingenieros de Caminos, Madrid, 1994.*
- *"Transportes", Ibeas, A., Díaz, J.M. Servicio de Publicaciones, E.T.S.I.C.C.P. Santander, 1998.*

Assessment:

A final exam will be held covering the whole contents of the subject.

Personal Tutorials:

At the beginning of the course lecturers will post their tutor hours.

Additional Information:

An elementary knowledge of Transport Engineering is recommended.

Syllabus:

1. **TRANSPORT PLANNING**
   Basic Concepts. Transport Planning Historical Development. The Transport Planning Process. Integral and Sectorial Transport Planning.

2. **TRANSPORT PLANNING IN SPAIN**
   Highways planning in Spain. Highways Plans in the Autonomous Communities. Railroads Planning in Spain. Port Planning. The "Plan Director de Infraestructuras" (General Plan of Infrastructures).

3. **EUROPEAN UNION TRANSPORT POLICY**
   New concept of Europe. The concept of 'European interest'. The TASC system. The European Union treaties. The institutional frame in the European Union. The financial system in the EU. The financial system in the Spanish autonomous communities and the European founding. The common transport policy. The founding of the infrastructures of European interest.

4. **TRANSPORT PLANNING STUDIES**
   Introduction. Inventories. Studies: Classification, Volume, Capacity, Pedestrian, Mass Transit, Parking, Origin-Destination, Traffic Impact.

5. **TRANSPORT MODELS**
   Aggregated and non-aggregated models. Four-step models. Other models.

6. **TRANSPORT PROJECT EVALUATION AND CHOICE**
   Project Evaluation in the Transport Planning Process. Economic Analysis and Financial Analysis. Project Evaluation in the Public Sector. Uncertainty and risk in the assessment of projects. Benefit-Cost Analysis. Multi-criteria Analysis.

Technical Project

DEPARTMENT:	**T**
LECTURER IN CHARGE:	**Lecturers in the School**
OTHER LECTURERS:	
YEAR:	**4th and 5th**
TYPE:	**Option**
CREDITS:	**18 CC. 12 EC.**

Aims:

The technical project will consist of the carrying out and presentation, by each student, of a Civil Engineering project, which may consist of a definition in depth of the technological aspects of a Project, a Study or Report on an unconventional subject in the professional field, or a project related to Research and Development in Engineering.

Teaching Organization:

The lecturers in the School will formalize their proposals for the Technical Project at the beginning of each academic year. The students will be able to choose one of the subjects offered in agreement with the lecturer or lecturers who propose them, and who will act as tutor (or tutors) of the Technical Project.

Bibliography:

- *That which is indicated by the tutor or tutors in charge of the Technical Project.*

Assessment:

The project will be presented in the format established in the "Regulation of the Technical Project", following the suggestions of the tutor or tutors in charge of it. The assessment of each Technical Project will be carried out by a examining board designed for that purpose and which will be formed by three lecturers of the School. In the public act of assessment, the student will present and defend the project carried out. After the presentation, the board will retire to deliberate and will decide if the project is accepted or must be modified or amplified. Once all the projects presented in an assessment period have been evaluated, the marks of the Technical Project will be given.

Personal Tutorials:

Additional Information:

It is convenient to start the Technical Project between the fourth and fifth years.

Training Period

DEPARTMENT:
LECTURER IN CHARGE: **Academic Secretary of the School**
OTHER LECTURERS:

YEAR: **4th and 5th**
TYPE: **Option**
CREDITS: **6 CC. 4 EC.**

Aims:

The Academic Secretary of the School organizes and coordinates during each academic year a Training Period in firms and public and private institutions related to Civil Engineering, which allow completing the academic training of students by means of carrying out activities in the field of Civil Engineering.

Teaching Organization:

The requirements a student must fulfill for the carrying out of the training period, its content, duration and calendar, as well as the economic and working conditions and operation status are the ones detailed in the Regulation "Training Period" of the School.

Assessment:

Once the training period has finished, the student will send the Academic Secretary a report with detailed relation of the tasks and activities carried out during the training period. This report together with the one issued by the tutor appointed by the firm, will be assessed by a School Committee and will constitute the basis for the final mark of the student.

Personal Tutorials:

Additional Information:

It is advisable to carry out the Training Period at the end of the fourth year.

4. ACADEMIC CALENDAR and LECTURES AND ASSESSMENTS TIMETABLE

4.1. FIRST YEAR

E.T.S DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS UNIVERSITY OF LA CORUÑA	
ACADEMIC CALENDAR OF THE YEAR 2001/ 2002	
1st October	: Start of the lectures (1st four-month period)
5th October	: Inauguration of the academic year
8th October	: Public Holiday (*Our Lady of the Rosary feastday)*
12th October	: Public Holiday (Spanish National Holiday)
1st November	: Public Holiday (All Saints Day)
6th December	: Public Holiday (Day of the Spanish Constitution)
8th December	: Public Holiday (The Immaculate Conception)
22nd December until 7th January	: Christmas Holidays
21st January	: Last day of lectures (1st four- month period)
22nd January	: Public Holiday (St. Domingo of the Way)
23RD January until 9TH February	: Exam Period
28TH January	: Public Holiday (St. Thomas)
11th and 12th February	: Public Holiday (Carnivals)
13th February	: Start of the lectures (2nd Four-month period)
19th March	: Public Holiday (St. Joseph)
23rd March until 1st April	: Easter Holidays
1st May	: Public Holiday (Labour Day)
17th May	: Public Holiday (Galician literature festivity)
28th May	: Last day of lectures (2nd Four- month period)
29th May until 6th June	: Exam period
1st until 28th September	: Exam period

TIMETABLE					**FIRST YEAR**
Group A	Monday	Tuesday	Wednesday	Thursday	Friday
8: 30-9:20				IT	
9:30- 10:20				IT	
15:00-15:50	FA	C1		C1	FA
16:00- 16:50	A	MC	C1	FA	FA
17:00-17:50	C1	MC	A	FA	C1
18:15-19:05	T	A	A	MC	
19:15.20:05	DT	T	DT	MC	
20:15-21:05	DT	T	DT	A	
Group B					
8: 30-9:20				IT	
9:30- 10:20				IT	
15:00-15:50	A		A	A	C1
16:00- 16:50	C1	C1	A	C1	MC
17:00-17:50	FA	A	C1	DT	MC
18:15-19:05	FA	T	FA	DT	
19:15.20:05	T	DT	MC	FA	
20:15-21:05	T	DT	MC	FA	

COMPULSORY COURSES

A: Algebra
C1: Calculus I
DT: Technical Drawing
FA: Applied Physics
MC: Construction Materials
T: Surveying

OPTIONS / FREE CONFIGURATION COURSES

IT: Technical English

EXAMS TIMETABLE **FIRST YEAR**

FEBRUARY

		23/I	24/I	25/I	26/I
				FA(1P) 16:00 h.	
28/I	29/I	30/I	31/I	1/II	2/II
		A(1P) 16:00 h.		T(1P) 16:00 h	
4/II	5/II	6/II	7/II	8/II	9/II
C1(1P) 16:00 h.		MC(1P) 16:00 h.		DT(1P) 16:00 h	

JUNE

			23/V		
			IT(F) 9:00 h.		
		29/V	30/V	31/V	1/VI
				FA(2P) 16:00 h.	
3/VI	4/VI	5/VI	6/VI	7/VI	8/VI
T(2P) 16:00 h.		MC(2P) 16:00 h.		C1(2P) 16:00 h.	
10/VI	11/VI	12/VI	13/VI	14/VI	15/VI
DT(2P) 16:00 h.					
17/VI	18/VI	19/VI	20/VI	21/VI	22/VI
A(2P) 16:00 h.		T(F) 16:00 h.		FA(F) 16:00 h.	
24/VI	25/VI	26/VI	27/VI	28/VI	29/VI
MC(F) 16:00 h.		C1(F) 16:00 h.		DT(F) 16:00 h.	
1/VII					
A(F) 16:00 h.					

SEPTEMBER

2/IX	3/IX	4/IX	5/IX	6/IX	7/IX
T(F) 16:00 h.		FA(F) 16:00 h.		MC(F) 16:00 h.	
9/IX	10/IX	11/IX	12/IX	13/IX	14/IX
C1(F) 16:00 h.		A(F) 16:00 h.		IT(F) 16:00 h.	
16/IX					
DT(F) 16:00 h.					

1P: First Partial Exam 2P: Second Partial Exam F: Complete Course Contents Exam

4.2. SECOND YEAR

E.T.S DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS UNIVERSITY OF LA CORUÑA	
ACADEMIC CALENDAR OF THE YEAR 2001/ 2002	
1st October	: Start of the lectures (1st four-month period)
5th October	: Inauguration of the academic year
8th October	: Public Holiday (*Our Lady of the Rosary feastday)*
12th October	: Public Holiday (Spanish National Holiday)
1st November	: Public Holiday (All Saints Day)
6th December	: Public Holiday (Day of the Spanish Constitution)
8th December	: Public Holiday (The Immaculate Conception)
22nd December until 7th January	: Christmas Holidays
21st January	: Last day of lectures (1st four- month period)
22nd January	: Public Holiday (St. Domingo of the Way)
23RD January until 9TH February	: Exam Period
28TH January	: Public Holiday (St. Thomas)
11th and 12th February	: Public Holiday (Carnivals)
13th February	: Start of the lectures (2nd Four-month period)
19th March	: Public Holiday (St. Joseph)
23rd March until 1st April	: Easter Holidays
1st May	: Public Holiday (Labour Day)
17th May	: Public Holiday (Galician literature festivity)
28th May	: Last day of lectures (2nd Four- month period)
29th May until 6th June	: Exam period
1st until 28th September	: Exam period

TIMETABLE					**SECOND YEAR**
	Monday	Tuesday	Wednesday	Thursday	Friday
					First Four- Month Period
8:30– 9:20	EGAOP	C2	IMT	EGAOP	IMT
9:30–10:20	EGAOP	C2	IMT	EGAOP	IMT
10:45–11:35	GD	GMD	C2	GD	GMD
11:45-12:35	GD	A)HH1 B)E1	B)HH1	GD	C2
12:45-13:35	A)E1	A)HH1 B)E1	B)HH1	A)HH1 B)E1	A)E1
13:45-14:35	A)E1	B)HH1		B)E1	A)E1
16:00-16:50	A)FT		FT		
17:00-17:50			B)FT		
					Second Four- Month Period
8:30– 9:20	M	C2	IMT	M	IMT
9:30–10:20	M	C2	IMT	M	IMT
10:45–11:35	TT	GMD	C2	TT	GMD
11:45-12:35	TT	A)HH1 B)E1	B)HH1	TT	C2
12:45-13:35	A)E1	A)HH1 B)E1	B)HH1	A)HH1 B)E1	A)E1
13:45-14:35	A)E1	B)HH1		B)E1	A)E1
16:00-16:50	A)FT		FT		
17:00-17:50			B)FT		
18:00-21:00		ICD			

COMPULSORY COURSES

C2: Calculus II
GMD: Metric and Descriptive Geometry
IMT: Geology and Introduction to Geotechnical Eng
EGAOP: General and Applied to Public Works Economics
TT: Transports and Land Use
E1: Structures I
HH1: Hydraulics and Hydrology I
GD: Differential Geometry
M: Mechanics

OPTIONS / FREE CONFIGURATION COURSES

FT: Technical French

FREE CONFIGURATION COURSES

ICD: Introduction to Cooperation for Development

EXAMS TIMETABLE **SECOND YEAR**

FEBRUARY

		23/I	24/I	25/I	26/I
			HH1(1P) 16:00 h.		EGAOP(F) 9:30 h.
28/I	29/I	30/I	31/I	1/II	2/II
	GMD(1P) 16:00 h.		C2(1P) 16:00 h.		
4/II	5/II	6/II	7/II	8/II	9/II
	E1(1P) 16:00 h.		GD(F) 16:00 h.		

The date for the exam on IMT will be further posted

JUNE

		22/V			
		FT(F) 16:00 h.			
		29/V	30/V	31/V	1/VI
			HH1(2P) 16:00 h.		TT(F) 9:30 h.
3/VI	4/VI	5/VI	6/VI	7/VI	8/VI
	M(F) 16:00 h.		GMD(2P) 16:00 h.		C2(2P) 9:30 h.
10/VI	11/VI	12/VI	13/VI	14/VI	15/VI
	IMT(2P) 16:00 h.				E1(2P) 9:30 h.
17/VI	18/VI	19/VI	20/VI	21/VI	22/VI
	GD(F) 16:00 h.	ICD(F) 16:00 h.	HH1(F) 16:00 h.		EGAOP(F) 9:30 h.
24/VI	25/VI	26/VI	27/VI	28/VI	29/VI
	TT(F) 16:00 h.		M(F) 16:00 h.		GMD(F) 9:30 h.
1/VII	2/VII	3/VII	4/VII	5/VII	6/VII
	C2(F) 16:00 h.		E1(F) 9:00 Y16:00		IMT(F) 16:00 h.

SEPTEMBER

2/IX	3/IX	4/IX	5/IX	6/IX	7/IX
	HH1(F) 16:00 h.		TT(F) 16:00 h.		M(F) 9:30 h.
9/IX	10/IX	11/IX	12/IX	13/IX	14/IX
ICD(F) 16:00 h.	GMD(F) 16:00 h.		C2(F) 16:00 h.		IMT(F) 9:30 h.
16/IX	17/IX	18/IX	19/IX	20/IX	21/IX
	E1(F) 9:00 Y16:00	FT(F) 16:00 h.	GD(F) 16:00 h.		EGAOP(F) 9:30 h.

1P: First Partial Exam 2P: Second Partial Exam F: Complete Course Contents Exam

4.3. THIRD YEAR

E.T.S DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS UNIVERSITY OF LA CORUÑA	
ACADEMIC CALENDAR OF THE YEAR 2001/ 2002	
1st October	: Start of the lectures (1st four-month period)
5th October	: Inauguration of the academic year
8th October	: Public Holiday (*Our Lady of the Rosary feastday)*
12th October	: Public Holiday (Spanish National Holiday)
1st November	: Public Holiday (All Saints Day)
6th December	: Public Holiday (Day of the Spanish Constitution)
8th December	: Public Holiday (The Immaculate Conception)
22nd December until 7th January	: Christmas Holidays
21st January	: Last day of lectures (1st four- month period)
22nd January	: Public Holiday (St. Domingo of the Way)
23RD January until 9TH February	: Exam Period
28TH January	: Public Holiday (St. Thomas)
11th and 12th February	: Public Holiday (Carnivals)
13th February	: Start of the lectures (2nd Four-month period)
19th March	: Public Holiday (St. Joseph)
23rd March until 1st April	: Easter Holidays
1st May	: Public Holiday (Labour Day)
17th May	: Public Holiday (Galician literature festivity)
28th May	: Last day of lectures (2nd Four- month period)
29th May until 6th June	: Exam period
1st until 28th September	: Exam period

TIMETABLE					**THIRD YEAR**
	Monday	Tuesday	Wednesday	Thursday	Friday
					First Four- Month Period
8:30– 9:20	IT2	E2	E2	MMC	C3
9:30–10:20	IT2	E2	E2	MMC	C3
10:45–11:35	C3	IT2	MMC	ETD	MMC
11:45-12:35	C3	IT2	CN	ETD	MMC
12:45-13:35		ETD	CN	CN	
13:45-14:35				CN	
16:00-16:50	PI		PI		
17:00-17:50	PI		PI		
					Second Four- Month Period
8:30– 9:20	IT2	E2	E2	CMT	
9:30–10:20	IT2	E2	E2	CMT	CMT
10:45–11:35	HH2	IT2	CMT	ETD	CMT
11:45-12:35	HH2	IT2	CN	ETD	HH2
12:45-13:35		ETD	CN	CN	HH2
13:45-14:35				CN	
16:00-16:50	HA		HA		
17:00-17:50	HA		HA		

COMPULSORY COURSES

CN: Numerical Calculus
ETD: Statistics
E2: Structures II
IT2: Geotechnical Engineering II
CMT: Materials Science
MMC: Continuum Mechanics
C3: Calculus III
HH2: Hydraulics and Hydrology II

OPTIONS / FREE CONFIGURATION COURSES

HA: History of Art
PI: Landscape in Engineering

EXAMS TIMETABLE **THIRD YEAR**

FEBRUARY

		23/I	24/I	25/I	26/I
		C3(1P) 9:00 h.		E2(1P) 9:00 h.	
28/I	29/I	30/I	31/I	1/II	2/II
		MMC(F) 9:00 h.		ETD(1P) 9:00 h.	
4/II	5/II	6/II	7/II	8/II	9/II
IT2(1P) 9:00 h.		PI(F) 9:00 h.		CN(1P) 9:00 h.	

JUNE

		29/V	30/V	31/V	1/VI
		HA(F) 9:00 h.		HH2(F) 9:00 h.	
3/VI	4/VI	5/VI	6/VI	7/VI	8/VI
CN(2P) 9:00 h.		CMT(F) 9:00 h.		ETD(2P) 9:00 h.	
10/VI	11/VI	12/VI	13/VI	14/VI	15/VI
IT2(2P) 9:00 h.					
17/VI	18/VI	19/VI	20/VI	21/VI	22/VI
C3(F) 9:00 h.		E2(2P) 9:00 h.		MMC(F) 9:00 h.	
24/VI	25/VI	26/VI	27/VI	28/VI	29/VI
HH2(F) 9:00 h.		CN(F) 9:00 h.		CMT(F) 9:00 h.	
1/VII	2/VII	3/VII	4/VII	5/VII	6/VII
ETD(F) 9:00 h.		IT2(F) 9:00 h.		E2(F) 9:00 Y 16:00	

SEPTEMBER

2/IX	3/IX	4/IX	5/IX	6/IX	7/IX
HA(F) 9:00 h.		HH2(F) 9:00 h.		CN(F) 9:00 h.	
9/IX	10/IX	11/IX	12/IX	13/IX	14/IX
CMT(F) 9:00 h.		ETD(F) 9:00 h.		IT2(F) 9:00 h.	
16/IX	17/IX	18/IX	19/IX	20/IX	21/IX
C3(F) 9:00 h.		E2(F) 9:00 Y 16:00		MMC(F) 9:00 h.	
23/IX					
PI(F) 9:00 h.					

1P: First Partial Exam 2P: Second Partial Exam F: Complete Course Contents Exam

4.4. FOURTH YEAR

E.T.S DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS UNIVERSITY OF LA CORUÑA	
ACADEMIC CALENDAR OF THE YEAR 2001/ 2002	
1st October	: Start of the lectures (1st four-month period)
5th October	: Inauguration of the academic year
8th October	: Public Holiday (*Our Lady of the Rosary feastday)*
12th October	: Public Holiday (Spanish National Holiday)
1st November	: Public Holiday (All Saints Day)
6th December	: Public Holiday (Day of the Spanish Constitution)
8th December	: Public Holiday (The Immaculate Conception)
22nd December until 7th January	: Christmas Holidays
21st January	: Last day of lectures (1st four- month period)
22nd January	: Public Holiday (St. Domingo of the Way)
23RD January until 9TH February	: Exam Period
28TH January	: Public Holiday (St. Thomas)
11th and 12th February	: Public Holiday (Carnivals)
13th February	: Start of the lectures (2nd Four-month period)
19th March	: Public Holiday (St. Joseph)
23rd March until 1st April	: Easter Holidays
1st May	: Public Holiday (Labour Day)
17th May	: Public Holiday (Galician literature festivity)
28th May	: Last day of lectures (2nd Four- month period)
29th May until 6th June	: Exam period
1st until 28th September	: Exam period

TIMETABLE					**FOURTH YEAR**
	Monday	Tuesday	Wednesday	Thursday	Friday
					First Four- Month Period
8:30– 9:20	OH	CA	IA	FCL	FCL
9:30–10:20	OH	OH	IA	FCL	FCL
10:45–11:35	E3	OH	CA	PC	PC
11:45-12:35	E3	IA	CA	CA	PC
12:45-13:35	HS	E3	HS	CA	HAP
13:45-14:35	HS	E3	HS	HAP	HAP
16:00-16:50	MRC	MNA	U1	MRC	
17:00-17:50	MRC	MNA	U1	MRC	
18:15-19:05	DAV	DAV	U1	MNA	
19:15-20:05	DAV	DAV	U1	MNA	
					Second Four- Month Period
8:30– 9:20	EMCM	EMCM	EMCM	IA	ELC
9:30–10:20	EMCM	EMCM	IA	IA	ELC
10:45–11:35	IT3	PNT1	TDI/IT3	PC	PC
11:45-12:35	IT3	PNT1	TDI/IT3	ELC	PC
12:45-13:35	CDE	SU	CDE	ELC	HAP
13:45-14:35	CDE	SU	CDE	HAP	HAP
16:00-16:50	RPH	TDI	MSC/SU	MSC	
17:00-17:50	RPH	TDI	MSC/SU	MSC	
18:15-19:05	PNT1	CA2	CA2	RPH	
19:15-20:05	PNT1	CA2	CA2	RPH	

COMPULSORY COURSES

HAP: Reinforced and Prestressed Concrete
IA: Environmental Engineering
PC: Harbours and Coasts
CA: Roads and Airports
ELC: Electrical Engineering
OH: Hydraulic Works
EMCM: Steel Structures and Combined Construction

OPTIONS / FREE CONFIGURATION COURSES

CA2: Roads and airports II
CDE: Dynamic analysis of structures
DAV: Computer aided design and visualization
E3: Structures III
FCL: Railways
HS: Underground Hidrology
IT3: Geotechnical Engineering III
MSC: Materials and constructive systems
MRC: Rock Mechanics
MNA: Avanced numerical methods
PNT1: Bridges I
RPH: Water resources and hydraulic planning
SU: Urban Services
TDI: Decision taking in engineering
U1: Urbanism

EXAMS TIMETABLE **FOURTH YEAR**

FEBRUARY

		23/I	24/I	25/I	26/I
			HAP(1P) 9:00 h.	MNA(F) 9:00 h.	FCL(F) 9:30 h.
28/I	29/I	30/I	31/I	1/II	2/II
	PC(1P) 9:00 h.	HS(F) 9:00 h.	E3(F) 9:00 h.		IA(1P) 9:30 h.
4/II	5/II	6/II	7/II	8/II	9/II
U1(F) 9:00 h.	CA(F) 9:00 h.		OH(F) 9:00 h.	DAV(F) 9:00 h	MRC(F) 9:30 h.

JUNE

		29/V	30/V	31/V	1/VI
		CDE(F) 9:00 h.	HAP(2P) 9:00 h.		PNT1(F) 9:30 h.
3/VI	4/VI	5/VI	6/VI	7/VI	8/VI
RPH(F) 9:00 h.	EMCM(F) 9:00 h.	IT3(F) 9:00 h.	IA(2P) 9:00 h.	SU(F) 9:00 h.	
10/VI	11/VI	12/VI	13/VI	14/VI	15/VI
MSC(F) 9:00 h.	PC(2P) 9:00 h.				
17/VI	18/VI	19/VI	20/VI	21/VI	22/VI
	ELC(F) 9:00 h.	CA2(F) 9:00 h.	OH(F) 9:00 h.		CA(F) 9:30 h.
24/VI	25/VI	26/VI	27/VI	28/VI	29/VI
TDI(F) 9:00 h.	HAP(F) 9:00 h.		EMCM(F) 9:00 h.		PC(F) 9:30 h.
1/VII	2/VII	3/VII	4/VII	5/VII	6/VII
	IA(F) 9:00 h.				ELC(F) 9:30 h.

SEPTEMBER

2/IX	3/IX	4/IX	5/IX	6/IX	7/IX
E3(F) 9:00 h.	HAP(F) 9:00 h.	DAV(F) 9:00 h.	IA(F) 9:00 h.	MRC(F) 9:00 h.	EMCM(F) 9:30 h.
9/IX	10/IX	11/IX	12/IX	13/IX	14/IX
CDE(F) 9:00 h.	PC(F) 9:00 h.	PNT1(F) 9:00 h.	ELC(F) 9:00 h.	RPH(F) 9:00 h.	OH(F) 9:30 h.
16/IX	17/IX	18/IX	19/IX	20/IX	21/IX
IT3(F) 9:00 h.	HS(F) 9:00 h.	SU(F) 9:00 h.	CA(F) 9:00 h.	MSC(F) 9:00 h.	TDI(F) 9:30 h.
23/IX	24/IX	25/IX	26/IX	27/IX	28/IX
CA2(F) 9:00 h.	MNA(F) 9:00 h.	FCL(F) 9:00 h.	U1(F) 9:00 h.		

1P: First Partial Exam 2P: Second Partial Exam F: Complete Course Contents Exam

4.5. FIFTH YEAR

E.T.S DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS UNIVERSITY OF LA CORUÑA	
ACADEMIC CALENDAR OF THE YEAR 2001/ 2002	
1st October	: Start of the lectures (1st four-month period)
5th October	: Inauguration of the academic year
8th October	: Public Holiday (*Our Lady of the Rosary feastday)*
12th October	: Public Holiday (Spanish National Holiday)
1st November	: Public Holiday (All Saints Day)
6th December	: Public Holiday (Day of the Spanish Constitution)
8th December	: Public Holiday (The Immaculate Conception)
22nd December until 7th January	: Christmas Holidays
21st January	: Last day of lectures (1st four- month period)
22nd January	: Public Holiday (St. Domingo of the Way)
23RD January until 9TH February	: Exam Period
28TH January	: Public Holiday (St. Thomas)
11th and 12th February	: Public Holiday (Carnivals)
13th February	: Start of the lectures (2nd Four-month period)
19th March	: Public Holiday (St. Joseph)
23rd March until 1st April	: Easter Holidays
1st May	: Public Holiday (Labour Day)
17th May	: Public Holiday (Galician literature festivity)
28th May	: Last day of lectures (2nd Four- month period)
29th May until 6th June	: Exam period
1st until 28th September	: Exam period

			TIMETABLE		**FIFTH YEAR**
	Monday	Tuesday	Wednesday	Thursday	Friday
					First four- month period
8:30– 9:20		HAP2	HAP2	CRT	CRT
9:30–10:20		HAP2	HAP2	CRT	CRT
10:45–11:35		TE	TE		PNT2
11:45-12:35		TE	TE		PNT2
12:45-13:35	PNT2	SE	IAOI	SE	IAOI
13:45-14:35	PNT2	SE	IAOI	SE	IAOI
16:00-16:50	ITRP	OTU	IM	OTU	HIC
17:00-17:50	ITRP	OTU	IM	OTU	HIC
18:15-19:05	OGPO	IM	ITRP	OGPO	
19:15-20:05	PFC	IM	ITRP	OGPO	
					Second four- month period
8:30– 9:20	PRS	PRS	ETFC	U2	ETFC
9:30–10:20	PRS	PRS	ETFC	U2	ETFC
10:45–11:35	DOE	IP	IP	DOE/U2	ISU
11:45-12:35	DOE	IP	IP	DOE/U2	ISU
12:45-13:35	CE	CE	DEP/IN	ISU/PT	PT
13:45-14:35	CE	CE	DEP/IN	ISU/PT	PT
16:00-16:50	EP	EP		DEP/IN	L
17:00-17:50	EP	EP		DEP/IN	L
18:15-19:05	OGE	OGE	OGPO	OGPO	
19:15-20:05	OGE	OGE		OGPO	

COMPULSORY COURSES

OGPO: Projects and Works Organization and Management
ITRP: Transport Engineering
HIC: History of Civil Engineering
OGE: Business Organization and Management
PFC: End of Degree Project
OTU: Regional and Urban Planning
EP: Building and Prefabrication
L: Legislation

OPTIONS / FREE CONFIGURATION COURSES

CE: Special foundations
DEP: Management and operation of harbours
ETFC: Railways technical operation
IM: Maritime engineering
U2: Urbanism II
IP: Harbour engineering
PT: Transport planning
PRS: Dams
TE: Tipology of structures
CRT: Control and regulation of traffic
DOE: Optimum design of structures
HAP2: Reinforced and prestressed concrete II
IN: Nuclear engineering
IAOI: Environmental impact of engineering works
ISU: Engineering of urban sewage systems
PNT2: Bridges II
SE: Expert systems

EXAMS TIMETABLE **FIFTH YEAR**

FEBRUARY

		23/I	24/I	25/I	26/I
		OGPO(1P) 16:00 h.	SE(F) 16:00 h.	HAP2(F) 16:00 h.	
28/I	29/I	30/I	31/I	1/II	2/II
	CRT(F) 16:00 h.	IM(F) 16:00 h.	OTU(F) 16:00 h.	TE(F) 16:00 h.	
4/II	5/II	6/II	7/II	8/II	9/II
PNT2(F) 16:00 h.		ITRP(F) 9:00 h.	IAOI(F) 16:00 h.		HIC(F) 9:30 h

JUNE

		29/V	30/V	31/V	1/VI
		IN(F) 16:00 h.		OGE(F) 9:00 h.	
3/VI	4/VI	5/VI	6/VI	7/VI	8/VI
U2(F) 16:00 h.		OGPO(2P) 16:00 h.	PRS(F) 16:00 h.	DEP(F) 16:00 h.	L(F) 9:30 h.
10/VI	11/VI	12/VI	13/VI	14/VI	15/VI
IP(F) 16:00 h.	DOE(F) 16:00 h.				
17/VI	18/VI	19/VI	20/VI	21/VI	22/VI
EP(F) 9:00 h.	CE(F) 16:00 h.	OTU(F) 16:00 h.	PT(F) 16:00 h.	OGE(F) 16:00 h.	
24/VI	25/VI	26/VI	27/VI	28/VI	29/VI
HIC(F) 16:00 h.	ETFC(F) 16:00 h	OGPO(F) 16:00 h.	ISU(F) 16:00 h.	L(F) 16:00 h.	
1/VII	2/VII	3/VII	4/VII	5/VII	6/VII
EP(F) 16:00 h.		ITRP(F) 16:00 h.			

Deadline for the submission of End of Degree Projects and Technical Projects 5/VII/2002

SEPTEMBER

2/IX	3/IX	4/IX	5/IX	6/IX	7/IX
OGPO(F) 16:00 h.	SE(F) 16:00 h.	OGE(F) 16:00 h.	HAP2(F) 16:00 h.	ITRP(F) 16:00 h.	CRT(F) 9:30 h.
9/IX	10/IX	11/IX	12/IX	13/IX	14/IX
HIC(F) 16:00 h.	TE(F) 16:00 h.	OTU(F) 16:00 h.	IM(F) 16:00 h.	L(F) 16:00 h.	IAOI(F) 9:30 h.
16/IX	17/IX	18/IX	19/IX	20/IX	21/IX
EP(F) 16:00 h.	IN(F) 16:00 h.	PRS(F) 16:00 h.	U2(F) 16:00 h.	PNT2(F) 16:00 h.	IP(F) 9:30 h.
23/IX	24/IX	25/IX	26/IX	27/IX	28/IX
DEP(F) 16:00 h.	DOE(F) 16:00 h.	CE(F) 16:00 h.	ISU(F) 16:00 h.	ETFC(F) 16:00 h.	PT(F) 9:30 h.

Deadline for the submission of End of Degree Projects and Technical Projects 30/IX/2002

1P: First Partial Exam 2P: Second Partial Exam F: Complete Course Contents Exam